

GREEN ARROW

A new locomotive for Gauge One, designed and described by Martin Evans

FOR MANY YEARS now, we at *Model Engineer* have been asked to describe a modern Gauge I high-pressure locomotive which would be suitable for either light passenger hauling or for the outdoor "scenic" model railway.

The last Gauge I locomotive to be described in "M.E." was the free-lance 4-4-0 *Newbury*, which was a very early design by the late J. N. Maskelyne, apart from its cylinders, which were of Messrs. Bond's standard pattern. I remember that *Newbury* came in for some criticism at the time, on the grounds that the cylinders and motion were out of date, having rather small ports and passages, and the late LBSC promptly came up with an alternative design, using separate cylinders with large ports and longer valve travel.

But *Newbury* was never intended to be a passenger-hauler; it was spirit fired and had a small and very easy to build water-tube boiler, and "J.N.M." considered the engine adequate for hauling 6 to 8 coaches on the average "scenic" railway.

I have never liked spirit firing in model locomotives, except in the very smallest scales; I like petrol or paraffin firing even less! To design a Gauge I engine which can regularly haul a "live" load, while retaining a reasonable scale outward appearance, seemed to me to call for either propane or coal firing. Now coal firing in Gauge I work is rather a tricky business; the fire is so small that unless it is continually watched and fed regularly every few minutes, it quickly dies out.

The answer therefore was to choose a prototype

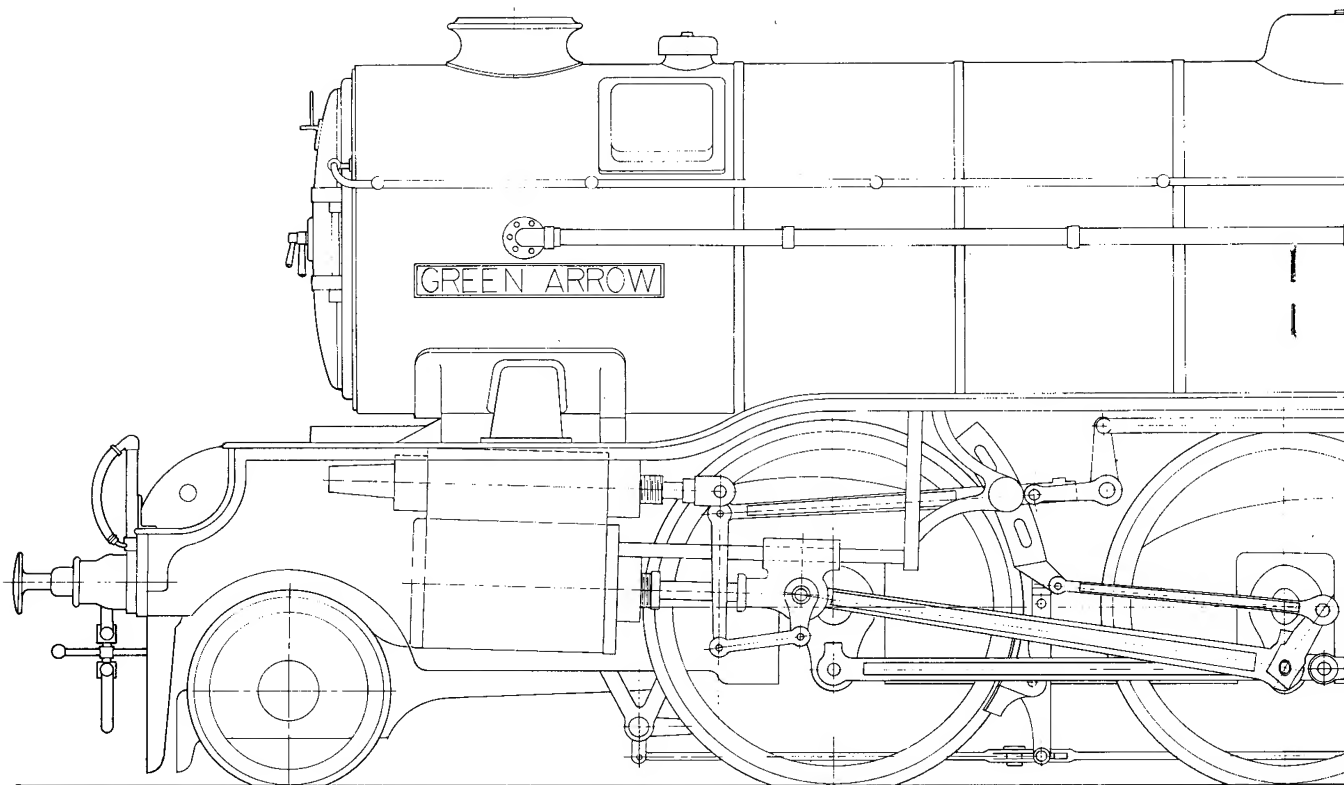
with a big firebox. An L.M.S. "Pacific" was the first thought, but the four cylinders and conjugated valve gear seemed rather a handicap, and the L.M.S. type of wide firebox boiler is rather difficult to make. My choice therefore fell upon the well-known 2-6-2 "Green Arrow" class, which had everything to recommend it—three large cylinders, though only two will be specified for the model, wide firebox boiler of the "round top" variety, making for ease of construction, and a tender of ample capacity, yet of simple shape.

The next problem was—could the same boiler be used for either coal or propane firing? The answer, I think, is yes, provided that the tubes are made large enough to prevent their becoming choked by cinders, in the case of coal firing. But for the most efficient use of propane, the tubes need to be rather small in diameter— $\frac{1}{4}$ in. O.D. is probably the optimum size—so I propose to describe two boilers, of the proper locomotive type, which will be identical apart from the tube arrangement.

Before we go any further with the requirements of the model, a few notes on the full-size engines may be of interest.

The "Green Arrows" were generally regarded, along with the streamlined "A.4's", as Gresley's most successful engines. They were intended as mixed-traffic engines, to replace the big "K.3" Moguls on fast goods trains and also to assist on express work.

For the boiler, Gresley decided on a similar one to that fitted to his "Pacifics" but with the



barrel shortened by 1 ft., to 17 ft. It was 6 ft. 5 in. diameter at the firebox end and tapered to 5 ft. 9 in. dia. at the smokebox. The working pressure was 220 p.s.i. Heating surfaces were: tubes 2216 sq. ft., firebox 215 sq.ft., superheater 679.7 sq.ft., and grate area 41.25 sq.ft.

The three cylinders were 18½ in. × 26 in. stroke, similar to those of the "A.4's". The cylinders, steam chests and smokebox saddle were cast in one piece, into which liners were shrunk.

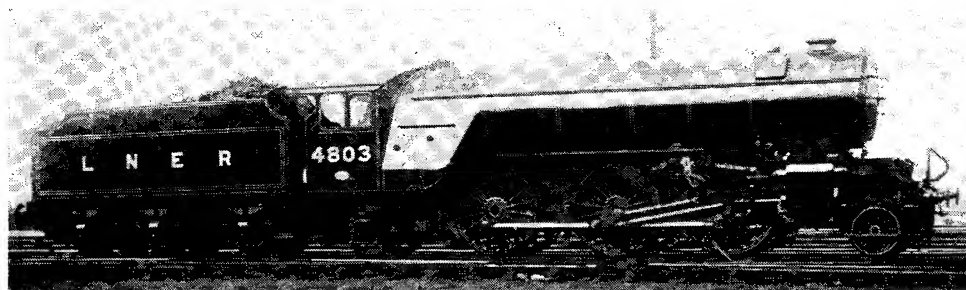
With driving and coupled wheels of 6 ft. 2 in. dia., the tractive effort, at 85% of the boiler pressure, amounted to the useful figure of 33,730 lb.

Classified "V.2", the first "Green Arrow" was completed at Doncaster in June 1936. It was

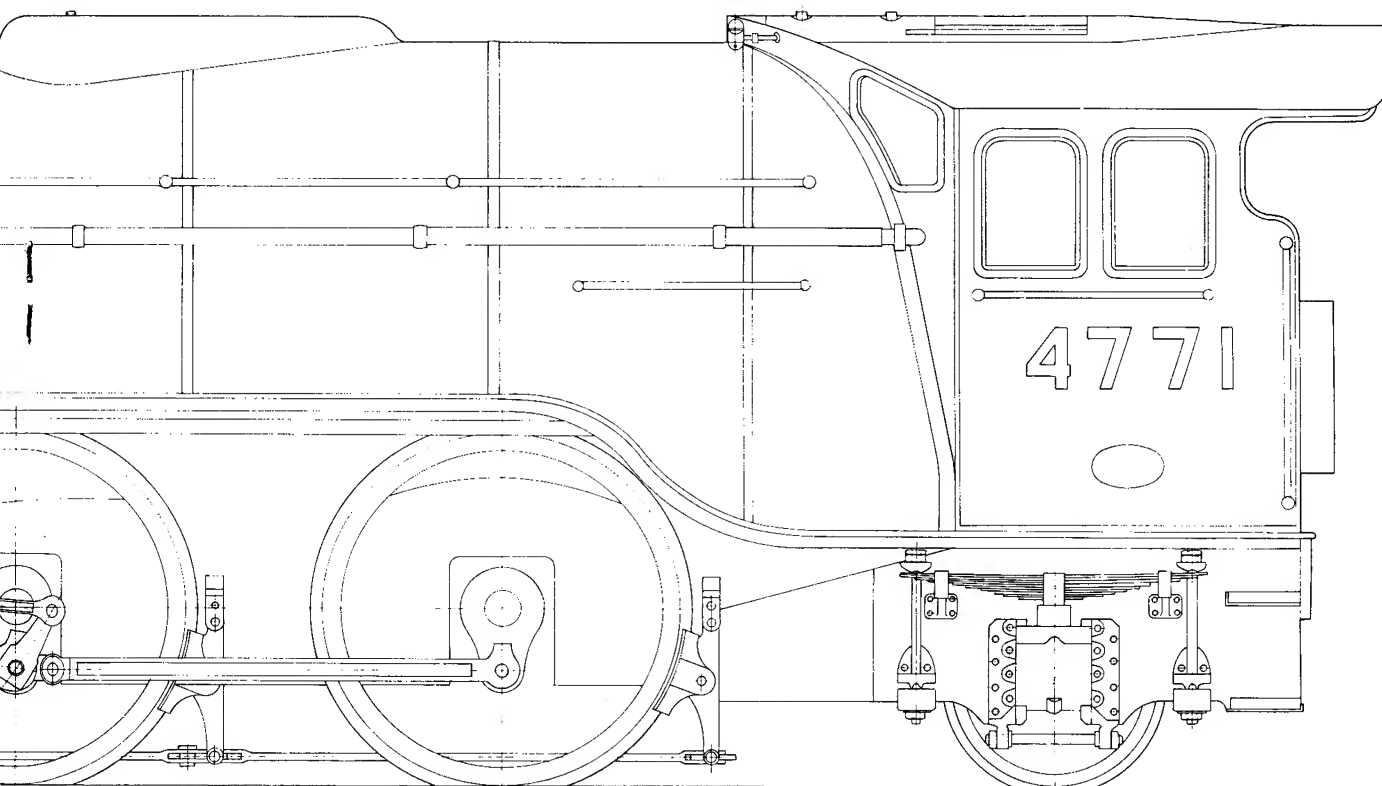
finished in the full passenger green livery and was generally considered at the time a fine-looking engine.

The first five 2-6-2's, Nos 4771-5, were distributed to sheds over the L.N.E.R. system between King's Cross and Dundee. After thorough testing of the first batch, the class were allocated to Scottish turns formerly worked by North British "Atlantics", both between Edinburgh and Aberdeen and on the "Waverley" route to Carlisle.

South of the Border, the "Green Arrows" were soon working all over the former Great Northern and North Eastern main lines and later on trains from the ex-Great Central Marylebone terminus; they proved successful everywhere.



*Green Arrow class
No. 4803,
one of the
Darlington
built
engines.*



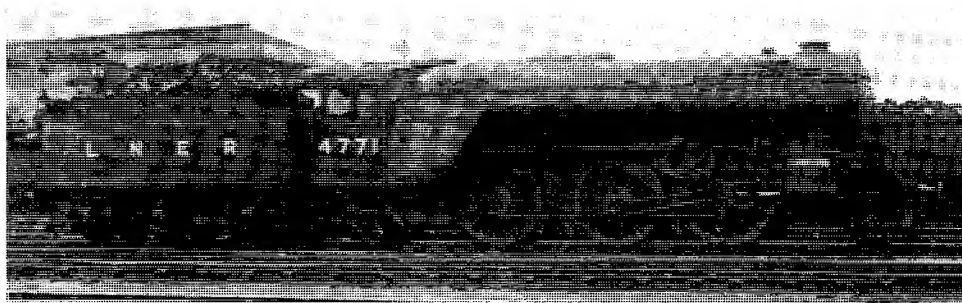
On one run with the "Yorkshire Pullman", No. 4817 reached 93 m.p.h. while No. 4789 had to take over the "West Riding Limited" streamlined express at short notice from the usual "A.4" "Pacific", and succeeded in covering the 185.8 miles between King's Cross and Leeds in 2 hours 47 minutes, only 4 mins. outside the scheduled time.

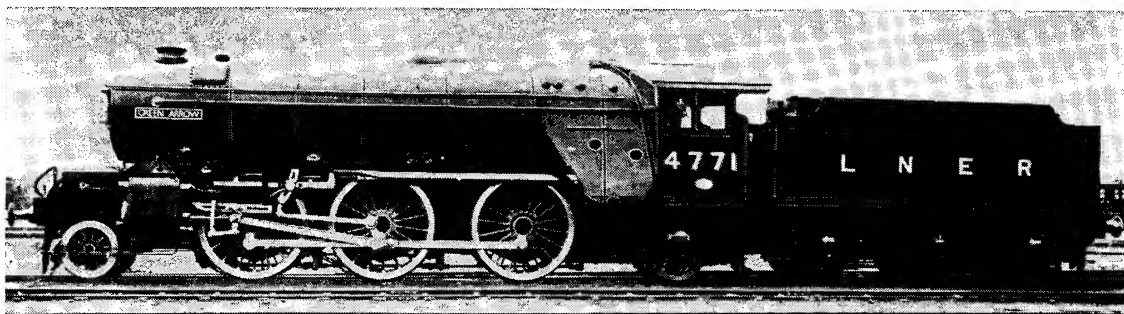
Late in 1938, No. 4806 "The Green Howard" was fitted with a multiple-valve regulator header in the smokebox, operated by an external rod. The last "V.2's" were ordered after Gresley's death, construction continuing until 1944, making a total of 184 engines.

The "V.2's" were a great asset between 1939 and 1945, when they handled very heavy passenger and troop trains. What is thought to have been the heaviest express train ever worked on the L.N.E.R. was hauled from Peterborough to King's Cross by No. 4800 during 1940. The train, which was of 26 bogie coaches, weighed approximately 850 tons. So long was it, that when it came to rest at King's Cross Station, the last four coaches were still in Gasworks Tunnel!

In my next article, I hope to describe the first components for the Gauge I model—the main and trailing frames, buffer beams and axleboxes.

*Off-side view
of the
original engine
"Green
Arrow"
Photographs
courtesy
Real
Photographs
Co.*





GREEN ARROW

A new locomotive for Gauge One

Described by Martin Evans

Part II

Continued from page 1015

HERE ARE THE DRAWINGS of the main frames and the preliminary details of our Gauge I *Green Arrow*. I expect the first reaction of the exponents of this gauge will be surprised at the thickness of the frames. I know that $\frac{1}{16}$ in. is generally regarded as quite strong enough and the usual for Gauge I engines.

However, I had a very good reason for specifying $\frac{3}{32}$ in. thickness. If $\frac{1}{16}$ in. material is used, there is not quite enough width to give adequate bearing surfaces for the main axleboxes working in the slots, so that it would have been necessary to fit hornblocks or separate horns, and this would have involved us in the trouble and expense of fitting castings. But with a frame thickness of $\frac{3}{32}$ in., the bearing area is increased by 50%, and we can safely dispense with horns. Apart from this, the thicker material will add considerably to the weight of the locomotive, and we need as much weight in a model of this kind as we can get.

As far as I can see, there is only one objection to the use of $\frac{3}{32}$ in. thick frames, and that is that the extreme parts of the frames, above buffer beam level, will be very prominent and would look terribly out of scale if something is not done about it. However, there is an easy way out of this problem. Mark out on the frames the outline of the footplating at this point, taking this from the general arrangement drawing, and file the frames away on the inside only, up to this line, until the thickness of the metal on the top edge is about $\frac{3}{16}$ in. This will give a nice scale appearance, and the fact that the frames are really slightly tapered at this point will not matter at all; it will be

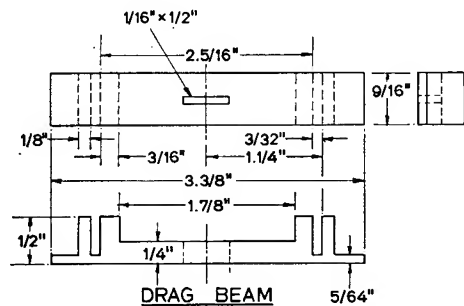
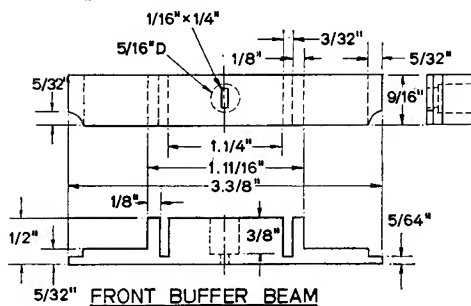
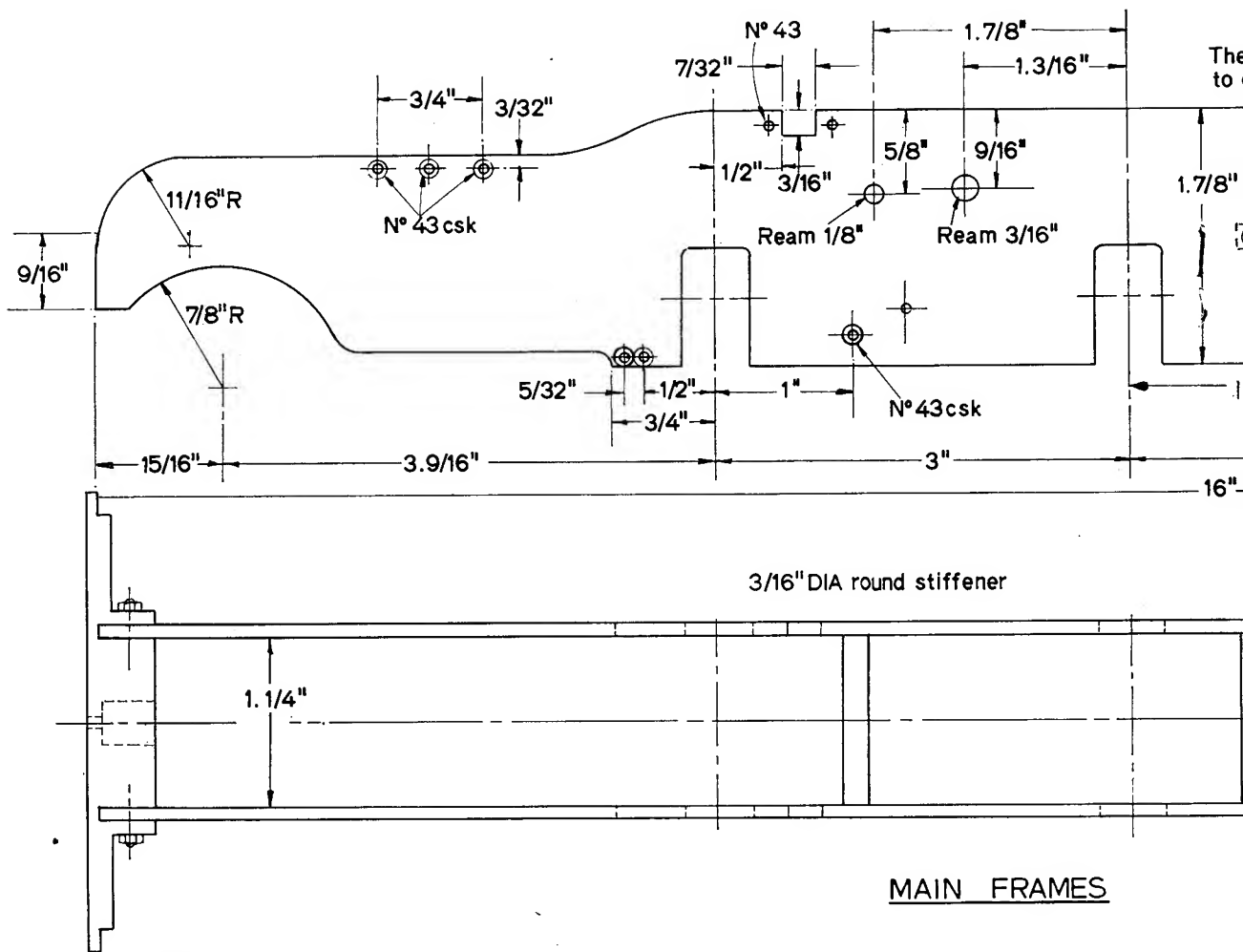
almost impossible to spot this, on the completed locomotive, if it is done carefully.

As will be seen, the trailing frames are bent up from a single piece of steel, and to ensure getting uniform bends, beginners are advised to make a wooden former first. It will also be found easier to get nice true bends if the material is left at the full $1\frac{1}{16}$ in. width while the bending is carried out, cutting it down to the dimensions shown afterwards.

Details are given of a simple main stretcher, which can be made from a gunmetal casting or built up from mild steel. But builders should note that this stretcher is only required *if no mechanical feed pump is to be fitted*. I know some Gauge I builders are quite happy with a tender hand pump only, though I would much rather have an axle-driven pump with the usual by-pass arrangement myself. For those wishing to fit the pump, drawings of a modified main frame stretcher, using the same fixing holes, will be published in the next issue, plus the details of the pump itself.

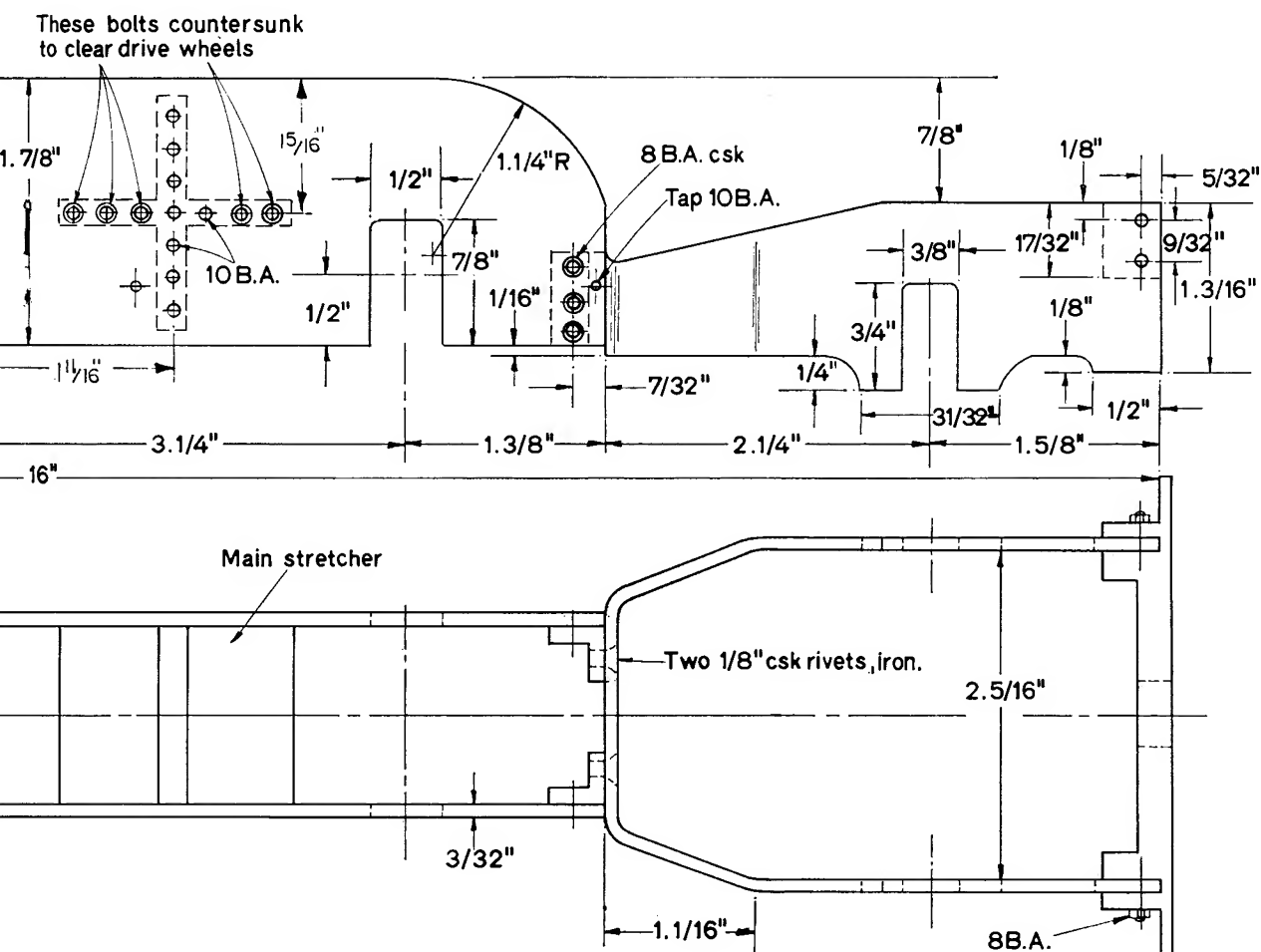
There is one other frame stretcher—a plain round one $\frac{3}{16}$ in. dia. which is situated just to the rear of the slot for the leading coupled axlebox.

I should perhaps mention that the holes for bolting the cylinders to the frames had not been decided when this drawing was sent to the block-makers, the reason being that I was trying to work in the cylinder castings which the late LBSC specified for his L.M.S. 4-6-0 *Dot*. However, a separate drawing showing any holes required will appear next time.



Regarding the question of fixing the frames to the buffer beams: it will be noticed that instead of using bright steel angle for the buffer and drag beam, $\frac{9}{16}$ in. \times $\frac{1}{2}$ in. material is called for. This may be either mild steel or brass. I think $\frac{9}{16}$ in. square can be obtained, and the odd $\frac{1}{16}$ in. can be quickly milled or turned away, using the four-jaw.

I would therefore suggest that the fixing holes should not be drilled in the frames first (the normal way), but that they should be drilled through the outer lug of the buffer and drag beams. The beams should be milled out to receive the frames, which are then pushed home and the drill run through them and through the inner part of the lug on the beam. A no. 50 drill should be used,



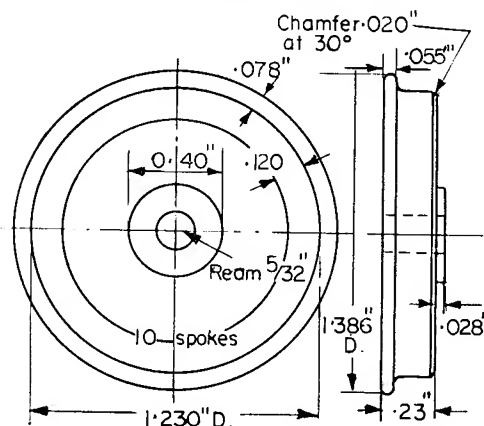
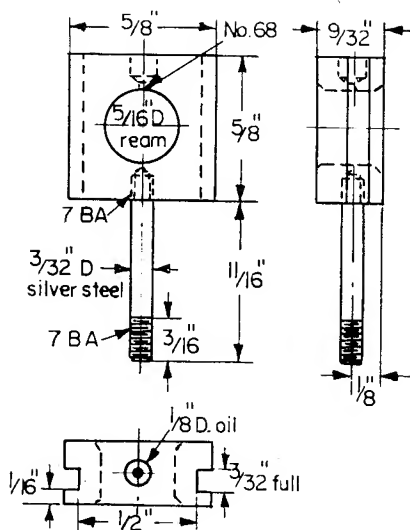
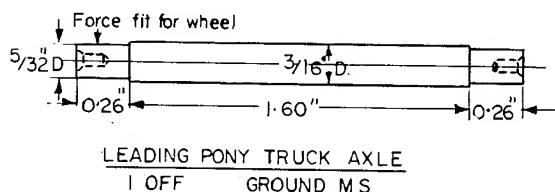
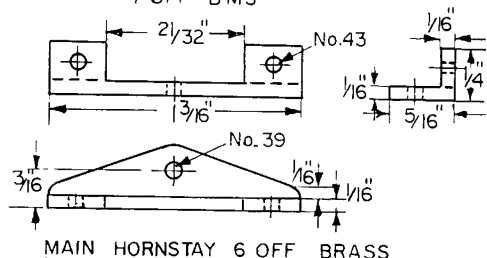
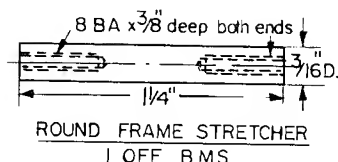
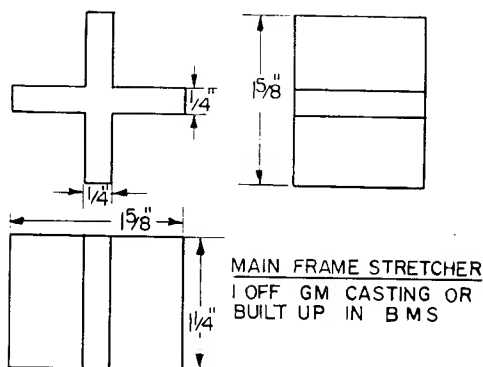
afterwards opening out the holes in the *outer* lug and the frames only, with No. 43 drill, the inner lug being tapped 8 BA. The dimensions for these fixing screws are shown on the trailing frame only, but they apply equally to the front end too of course.

To ensure plenty of strength, the main frames are joined to the trailing frames by $\frac{5}{8}$ in. lengths of $\frac{1}{2}$ in. \times $\frac{1}{2}$ in. \times $\frac{1}{2}$ in. steel angle. These angles are held to the trailing frames by two $\frac{1}{8}$ in. dia. iron rivets, while the main frames are held to the angles by three 8 BA steel countersunk screws. They have to be countersunk, otherwise they might be fouled by the trailing coupled wheels.

It will be noted that there are three 10 BA tapped holes, two are $1\frac{3}{8}$ in. to the rear of the leading and driving axle centres, while the third is $1\frac{1}{8}$ in. to the rear of the trailing coupled axle centre. These are for brakes, if required.

When marking out the frames, take special care

over the $\frac{3}{16}$ in. dia reamed hole which is $1\frac{1}{8}$ in. ahead of the driving axle centre, and the $\frac{1}{8}$ in. dia. reamed hole which is $1\frac{7}{8}$ in. ahead of same. These are for the weighshaft and expansion link "lining-up hole" respectively. The $\frac{3}{16}$ in. \times $\frac{3}{8}$ in. slot just ahead and above these two holes is to take the combined motion plate and link bracket. This item is always rather a problem in the Gresley three-cylinder locomotives—the 2-6-2's, 2-6-0's and 2-8-0's, though it doesn't apply in the case of the "Pacifics", where the motion plates and link brackets were separate castings. In the Gauge I model, I think it best if the left and right hand brackets are combined by means of a stretcher right across the frames, fitting into the slots I have just mentioned, with lugs on the inside of the frames to take screws put through the No. 43 holes on each side of the slot. This arrangement was used on my *Nigel Gresley*.



Axleboxes

The main axleboxes are very simple, and could be machined from drawn gunmetal or phosphor-bronze bar $\frac{5}{8}$ in. \times $\frac{1}{16}$ in. (commercial size). Cut a length sufficient for all six axleboxes (say 4 in.) and mill or turn down to a uniform thickness of $\frac{3}{32}$ in. The $\frac{3}{32}$ in. slot is best milled, using a slotting cutter between centres or on a short arbor in the three-jaw. The axlebox bar can be held on a length of steel angle bolted to the vertical-slide, or it could be held in a machine vice bolted directly down on the cross-slide with suitable packing to bring it up to the required height. It all depends on one's lathe and equipment of course. This is one of those operations that can take a great deal of time setting up, but the actual machining time is only a few minutes.

Some builders may prefer to mark off the bores in the bar, and drill and ream on the drilling machine table, others will clamp the bar on its side on the top-slide, and drill from the headstock, moving the top-slide forward for each bore. In this case, the bar must be packed up to exact lathe centre height. As very few builders will possess a height gauge, which is the ideal instrument to locate the bores accurately in the middle of the bar, it is not a bad plan to make a "trial" drilling, then insert a short piece of silver-steel rod and check whether this is central. If not, set the bar up again on the top-slide and adjust the packing strips accordingly. Replace the drill by an end-mill rather larger in diameter; put this through,

then bore to a few thou under $\frac{5}{16}$ in. dia., finishing with a reamer.

Another way of making these axleboxes is to drill and ream the bores first, then put the slots in by end milling, the bar being clamped on its side on a short stub of $\frac{5}{16}$ in. dia. silver steel, threaded, and fitted with a nut and washer. The stub is pressed into a suitable bar clamped under the tool-holder, or against a vertical-slide. In this method, the axleboxes are first cut off and faced to correct length. After milling the first slot, the axlebox is rotated

180 deg. and the second slot cut.

The hornstays are very simple; they are cut from $\frac{5}{16}$ in. \times $\frac{1}{16}$ in. brass angle. The bogie wheels, for which I hope suitable castings will be available, are machined to the B.R.M.S.B. dimensions. As wheel turning has been described many times recently, I won't bore readers with a repetition, except to say that the lathe should be run at full speed when drilling the wheels (use No. 24 drill) and then slowly for reaming $\frac{3}{32}$ in. dia.

To be continued

Model Engineering in the Nineteenth Century

Part II

by Colin R. Tyler

Continued from page 1004

DURING THE 1800's the progress of the model engineering hobby was spasmodic both in models built and their quality. The ease with which information can be obtained today was not the case 100 years ago and it was a question of making a model largely from memory or not at all. At least full marks must be awarded for those who tried in spite of the difficulties.

Nevertheless, in the latter part of the 19th century an ever-growing body of enthusiasts were making models until in 1898 *Model Engineer* was first published to fulfil the undoubted need for information and ideas. By this time the term "model engineering" covered many subjects other than the steam engine, although the history of models has its roots deeply embedded in and is closely allied to the development of steam.

As already mentioned in the previous articles locomotives, marine, aeronautical, electrical and many other subjects were dealt with, but not generally associated with model engineering until the latter part of the 19th century, when they tended to bond together under the one main heading, aided to a large extent by the first issues of this magazine, or as it was then called "The Model Engineer and Electrician". It seems to be a complete cycle of history today, that as most of the individual subjects are now so popular in their own right, once again they are all dealt with in their own specialist fields—as far as hobbies are concerned—each having its own magazines, societies and clubs.

As we have seen, in the early days of the hobby the limitations of manufacturing anything at home prevented many who were interested from attempting to make working models.

Emphasis has always been on working models as being preferred to non-working, for the good reason that a model made of metal and well built

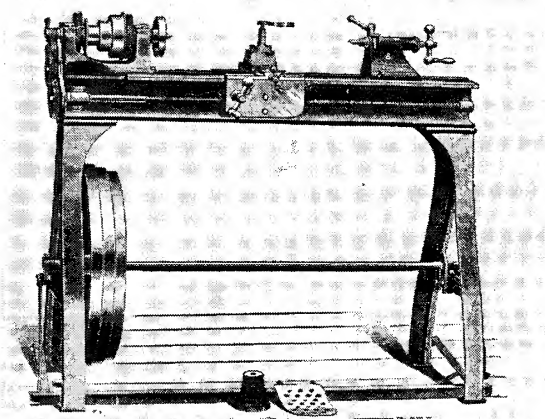
can be made a working model with comparatively little extra effort. On the other hand a non-working model can be made from materials which do not require a workshop, thereby taking it out of the subject of model engineering into another category—modelling—another hobby requiring much skill but only concentrating on appearance.

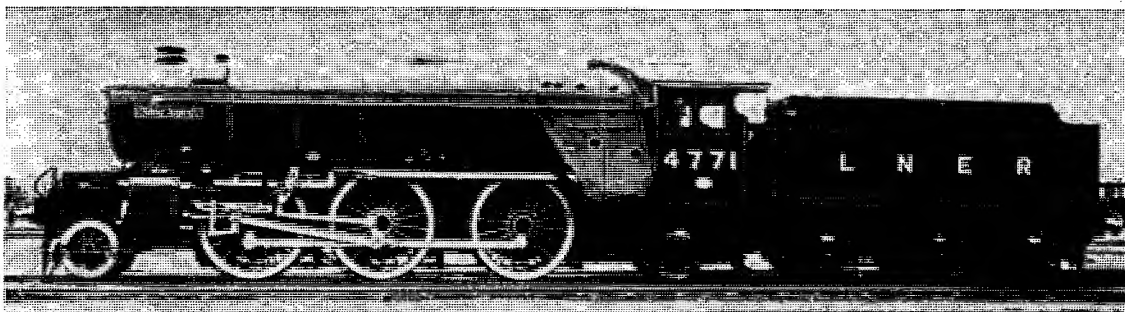
Steam being the adaptable power that it is, it followed that as the steam engine developed, so the number of people desiring to reproduce the new power in miniature should increase.

In the same year that the "Model Engineer and Electrician" was published, Percival Marshall invited some friends to the offices of Messrs. Dawbarn and Ward on October 4th. 1898. It was at this meeting that the Society of Model Engineers was founded. On November 2nd. a collection was made to raise funds at the first General Meeting held at the Memorial Hall, Farringdon Road.

At the same hall on November 11th 1899, a

A typical lathe as used by model engineers in Victorian times.





GREEN ARROW

**A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2,
designed and described by Martin Evans**

Part III

Continued from page 1069

IN MY LAST ARTICLE on *Green Arrow*, I mentioned that the fixing holes in the frames for the cylinders had not, at that time, been decided, owing to the question of suitable cylinder castings being investigated. I have since noticed that no definite dimensions were then given for the location of the tapped holes for the brake hanger pins. These should be at a point $1\frac{3}{8}$ in. to the rear of the appropriate axle centre and $\frac{7}{16}$ in. up from the bottom edge of the frame. These dimensions apply however only to the leading coupled and driving axle. Owing to the proximity of the trailing frame, the brake hanger pin for the trailing coupled wheels must be put $\frac{1}{16}$ in. nearer to the axle centre, that is $1\frac{5}{16}$ in.

There is another small point to note while we are discussing frame dimensions: the three No. 43 countersunk holes for the screws holding the smoke-box saddle are located from the leading coupled axle, the rear hole being $1\frac{11}{16}$ in. ahead of this.

In view of these additional dimensions, I am showing the side elevation of the frames once again, so that there should be no confusion.

My drawings this time also show the modified frame stretcher which will be required if the axle-driven pump is to be fitted. This can be built up from $\frac{1}{4}$ in. and $\frac{3}{16}$ in. mild steel, the joints being brazed, or a gunmetal casting could be used.

The pump itself hardly needs a casting, the tee-shaped body could be quickly built up from two pieces of round gunmetal, $\frac{3}{8}$ in. and $\frac{5}{16}$ in. dia. Turn down the outside of the delivery valve box to $\frac{3}{32}$ in. dia. holding the pump by the lower end (suction valve box) in the three-jaw. Face the end,

drill right through No. 41, and follow up with No. 39, then open out with No. 23 drill. Form the valve seating with a $\frac{5}{32}$ in. D-bit, and tap $\frac{3}{16}$ in. \times 40 t. for the delivery unions.

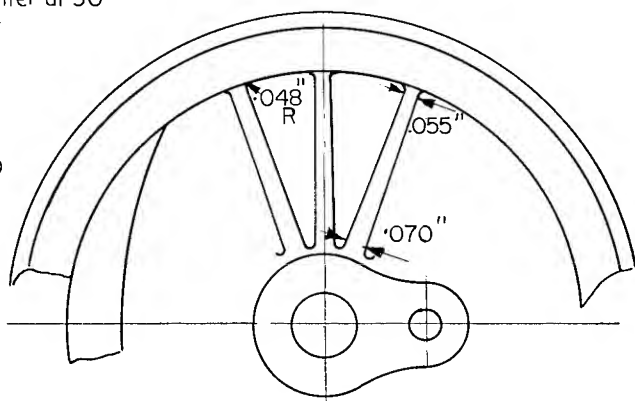
The fitting can now be reversed in the chuck, holding it by the $\frac{3}{32}$ in. dia., when the bottom can be opened out and tapped as before.

The top fitting has two branches, one for the pipe direct to the boiler clacks, and one for the by-pass. Both this and the bottom fitting can be cut from the solid, and brass can be used here.

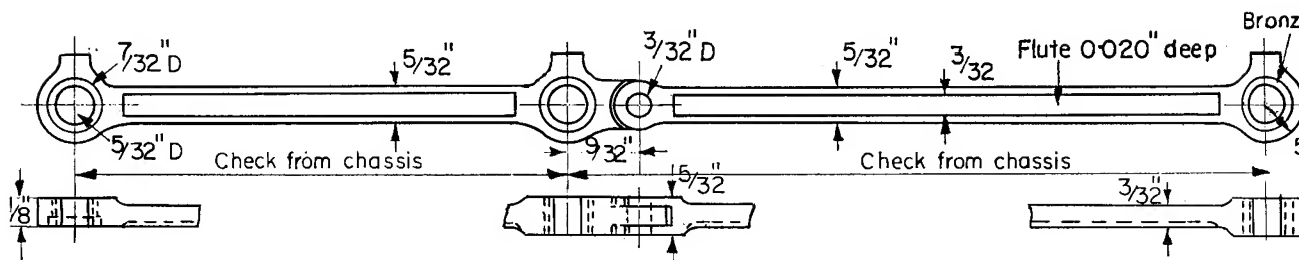
To machine the bore, set the pump body up in the four-jaw, turn the outside to $\frac{7}{16}$ in. dia., leaving $\frac{1}{16}$ in. shoulder of the full $\frac{3}{8}$ in. dia. Face the end, centre, drill No. 13, and finish with a $\frac{3}{16}$ in. D-bit. We cannot use a reamer here. Then drill into the passage with $\frac{7}{64}$ in. or No. 36 drill. The outside is threaded right up to the shoulder $\frac{5}{16}$ in. \times 40 t.

The $\frac{1}{8}$ in. dia. balls are seated in the usual way, using a light hammer and a length of brass rod with a recess to fit the ball, but make sure that the rod is held quite upright when hitting it. Ordinary steel balls can be used for this operation, and stainless steel balls put in on final assembly. To prevent the lower, suction, ball rising and blocking the "exit", it is a good plan to put in a small brass screw, 12 BA is quite big enough, as shown in the drawing, allowing for a ball lift of about $\frac{1}{32}$ in. The lower face of the delivery fitting, also, must be dealt with, and a slot can be filed here, to prevent the delivery ball trying the same trick. This ball, too, should have its lift restricted by the same amount.

The ram should be very easy to make. Cut a suitable length of $\frac{3}{16}$ in. dia. stainless steel, face one



DETAIL OF SPOKES

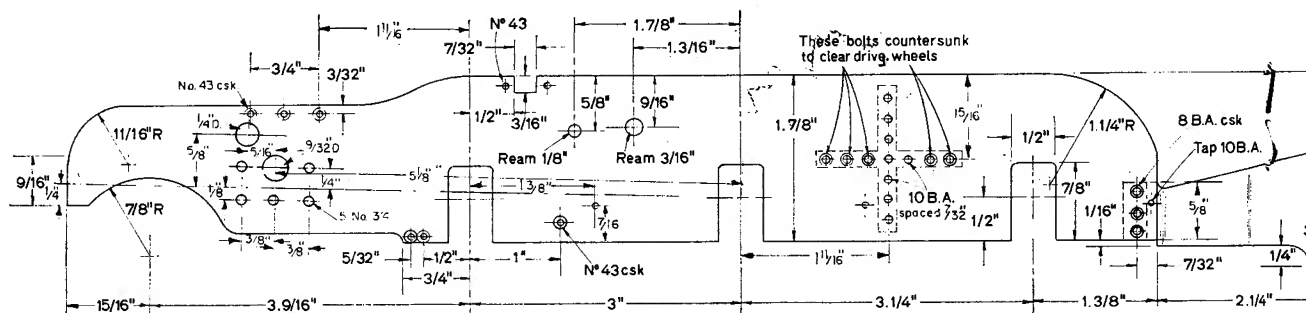


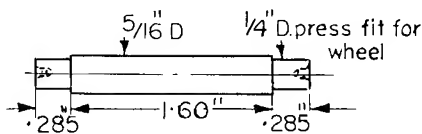
COUPLING RODS I L.H. I RH LH DRAWN BMS

clamp is tightened down, the ram will be firmly held. Make sure that the cross-hole is quite horizontal by inserting a length of $\frac{3}{32}$ in. silver steel through it, then mount a $\frac{1}{16}$ in. milling cutter on a short arbor or between centres, and cut the slot to a depth of $\frac{7}{32}$ in. Round the end for appearance sake.

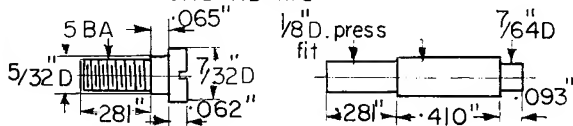
A gland nut, made from $\frac{7}{16}$ in. a/f gunmetal will

MAIN & TRAILING FRAMES



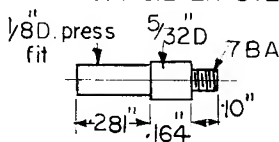


DRIVING & COUPLED AXLE 3 OFF
GROUND M.S.

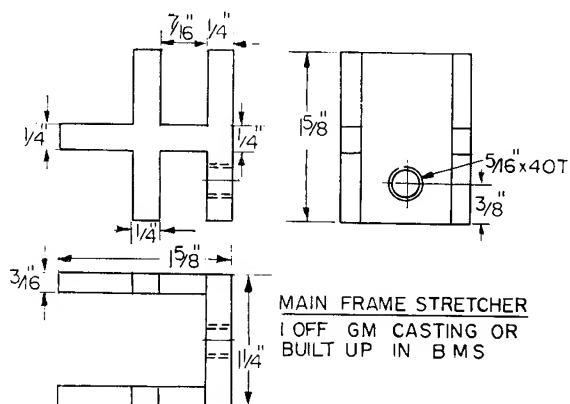
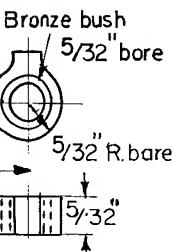


LEADING CRANKPIN
2 OFF SILVER STEEL

DRIVING CRANKPIN
2 OFF SILVER STEEL



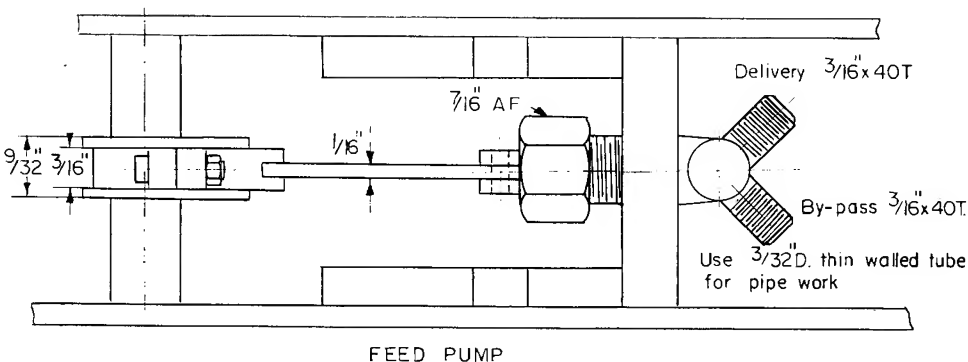
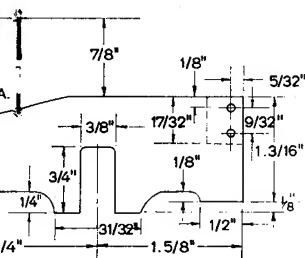
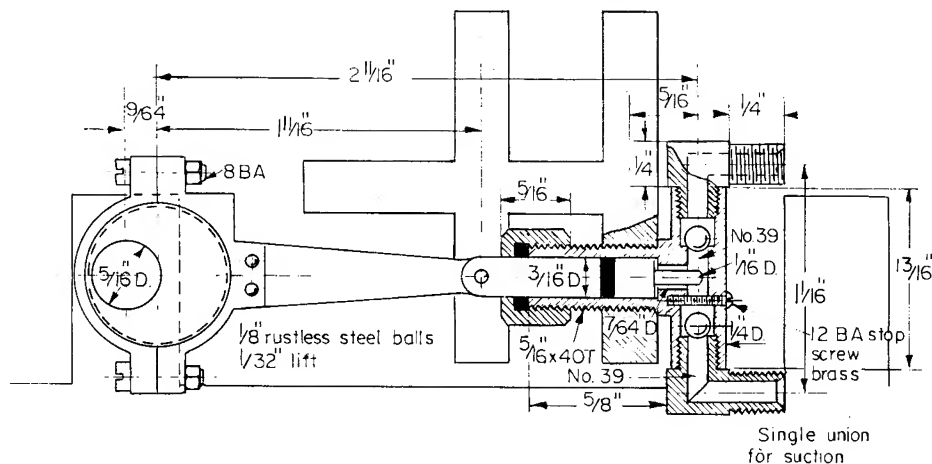
TRAILING CRANKPIN 2 OFF
SILVER STEEL



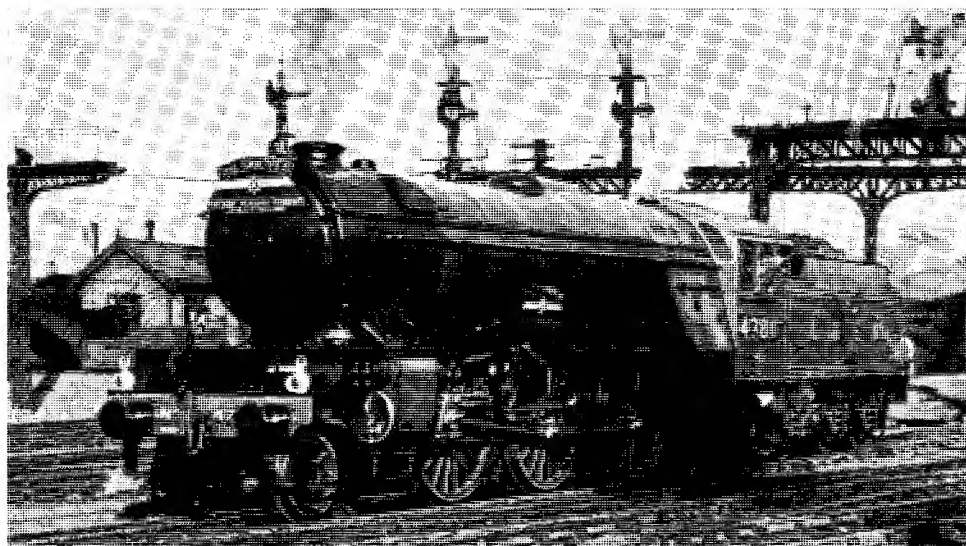
MAIN FRAME STRETCHER
1 OFF GM CASTING OR
BUILT UP IN B.M.S.

now be required. This is reamed $\frac{3}{16}$ in. dia., opened out with drills and D-bit to $\frac{3}{8}$ in. dia. and then tapped $\frac{1}{8}$ in. \times 40 t.

The eccentric can be made from $\frac{1}{8}$ in. dia. b.m.s., or the nearest larger available. It should measure $\frac{3}{8}$ in. dia. over the working diameter and a shade under $\frac{1}{8}$ in. dia. over the flanges. It is $\frac{3}{8}$ in. wide, so there should be no difficulty in getting it to run true on the $\frac{1}{8}$ in. axle. I know that some beginners have trouble in getting their eccentrics true, so I



FEED PUMP



One of the few "Green Arrow" class locomotives to receive names was No. 4780 "The Snapper, The East Yorkshire Regiment".

Photograph:
Real
Photographs
Co.

would suggest the following method: Measure the length of the jaws of the four-jaw chuck, that is—the amount they project from the body of the chuck. Then cut a length of the steel bar to be used for the eccentric to this length plus $\frac{7}{16}$ in., facing both ends beforehand.

Now chuck this piece in the three-jaw, and turn the whole eccentric to size, measuring the working diameter between the flanges with calipers. Keep the calipers set to this dimension for use later on the eccentric straps. To get a nice finish on the eccentric, use a tool shaped like a parting tool with the face exactly square, and the sharp edges removed, but with no appreciable radius. A fairly low speed should be used, and plenty of cutting oil.

Remove the bar from the chuck, and mark the centre to give the required throw, which is $\frac{9}{64}$ in. The centre of the eccentric can be found by the turning lines. Now put the bar into the four-jaw chuck, shifting the jaws until the new centre is running true (this is where a "wobbler" comes in very useful). Drill and ream $\frac{5}{16}$ in. dia. Run the lathe full speed for drilling, but dead slow for reaming, with cutting oil, and if only a few thou is left for the reamer to remove, the eccentric should be a nice fit on the locomotive axle.

Next, saw the unwanted piece off the bar, leaving $\frac{1}{2}$ in. or so for cleaning up. To finish machine the "sawn" side, a good dodge is to drill and tap for the fixing screw, which in this case could be a 4 or 5 BA Allen type grub-screw, and use this to hold the eccentric firmly on a short length of $\frac{5}{16}$ in. dia. steel held in the three-jaw chuck.

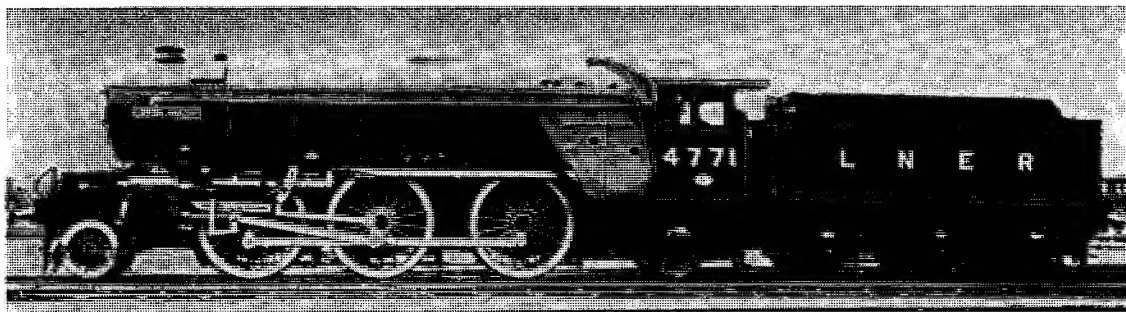
The eccentric straps are made from gunmetal castings, and the usual procedure for machining

them is to start by cleaning them up approximately to size all round, saw them in half, drill for the two fixing screws, in this case 8 BA steel or stainless steel, clean up the mating faces, then bolt together again for boring, holding them in the four-jaw. At this setting, one face can also be finished. Use the previously set calipers to get the bore to size. To finish the other side of the eccentric straps, use a scrap of $\frac{3}{4}$ in. dia. steel bar, and clamp the straps on this with a piece of thin paper between strap and bar, then they won't shift under the pressure of the turning tool.

Wheels

The drawings show all details of the driving and coupled wheels. As wheel turning has been dealt with so many times recently, I won't bore readers with yet another description, but I would call attention to the balance weights. On the "Green Arrow" class, the balance weights were not opposite to the crankpins—not even on the leading and trailing coupled wheels, on which the balance weights were 3 deg., out from the diametrically opposite position, and on the drivers, 13 deg. I am hoping that castings will be available for these wheels, and also for the more important cast components such as cylinders.

In Gauge 1 work, it is rather difficult to find enough clearance for the usual form of leading crankpin, so I think it would be safer to adopt the scheme used generally in the smaller gauges, that is to tap the wheel, and fit a screwed leading crankpin, with a large diameter head, working in a recess in the coupling rod boss. The driving crankpins are straightforward turning jobs from $\frac{3}{8}$ in. dia. silver steel, while the trailing pins are turned down on the outside for a 7 BA nut and washer.



GREEN ARROW

A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2, designed and described by Martin Evans

Part IV

Continued from page 1120

BEFORE GOING any further with the construction of our Gauge 1 *Green Arrow* I must say a few words about the dimensions so far given for the wheels and axles.

Several readers have pointed out that the dimensions I have shown for wheel "back-to-back", wheel thickness and boss (protrusion from wheel face) are not in fact to strict B.R.M.S.B. figures.

It would seem that most Gauge 1 enthusiasts today are working more or less strictly to the B.R.M.S.B. figure for back-to-back of 40 mm. which is approximately 1.58 in. As this is rather an important figure for good running, I am altering the back-to-back of my axles from 1.60 in. to 1.58 in., a reduction of 20 thou. To allow for this, the outside flanges of the driving axleboxes will have to be reduced by 10 thou each, i.e. to 0.052 in.

The wheel thickness specified (0.23 in.) should be quite satisfactory on any layout, but it will prove an advantage to reduce the amount the wheel boss protrudes from the face of the wheel. This should therefore be 0.021 in., giving a total thickness of 0.251 in. The only other parts affected by this alteration are the crankpins, the length of these which are pressed into the wheel now becoming 0.251 in. instead of 0.281 in., as given on page 1119.

To avoid possible confusion, these alterations are being incorporated into the full-size drawings, which will be available very shortly.

Coupling rods

Like the engine frames, the coupling rods may seem somewhat on the massive size, but using this heavy gauge of metal will be found much easier if it

is desired to mill the flutes (and no Gresley engine would look right without fluted rods!). In addition, the dimensions specified will give an engine that can run for a really long period before any re-bushing becomes necessary. What we really need is a section of bright mild steel $\frac{3}{8}$ in. \times $\frac{3}{8}$ in. This is not a commercial size, and it would be rather a nuisance filing, or milling down some $\frac{1}{16}$ in. thick material. However, as I understand that it is now possible to obtain steel flats in metric sizes, and 4 mm. thick will be one of the new "standard" sizes, this could be used. The difference would be hardly noticeable.

Start by checking the exact spacing required from the actual model, rather than taking the dimensions from the drawings. Make up the intermediate joint first, using a $\frac{3}{8}$ in. dia. pin-drill on the "male" end, and slotting the "female" end with a $\frac{1}{16}$ in. thick milling cutter. Then drill the three bearing holes an exact fit on the crankpins and try the rods on the engine. They will almost certainly be tight somewhere, so mark where they are binding, then open out the hole in the required direction with a small round needle file, afterwards drilling a larger size, for the bronze bushes, which may be $\frac{7}{32}$ in. dia. (maximum) and $\frac{3}{32}$ in. bore, to fit the crankpins. Do not fit the bushes yet however.

It is hardly worth while setting up to mill the shape of the coupling rods in Gauge 1 work, but the flutes will have to be milled. I think the best way to go about it is to first file the rods to the shape shown in the side elevation, but leaving them a little over the final width between the bosses. Don't thin the rods out in "plan" until after the

flutes have been put in, otherwise they will merely bend away from the milling cutter.

Mount a length of stout steel angle, say $1\frac{1}{2}$ in. \times $1\frac{1}{2}$ in. \times $\frac{3}{16}$ in., on the vertical-slide, arranged facing the lathe headstock and exactly horizontal (this can be checked by traversing the cross-slide right across, against a bent scribe in the chuck). The front and rear sections of the coupling rods can now be bolted down to the flat face of the angle, using steel screws put through the bosses. A $\frac{3}{32}$ in. Woodruffe cutter will then make short work of the fluting, which does not need to be deeper than 20 thou, so it can be done in one cut. The small diameter of the Woodruffe will leave nicely radiused "run-outs" with fairly sharp corners.

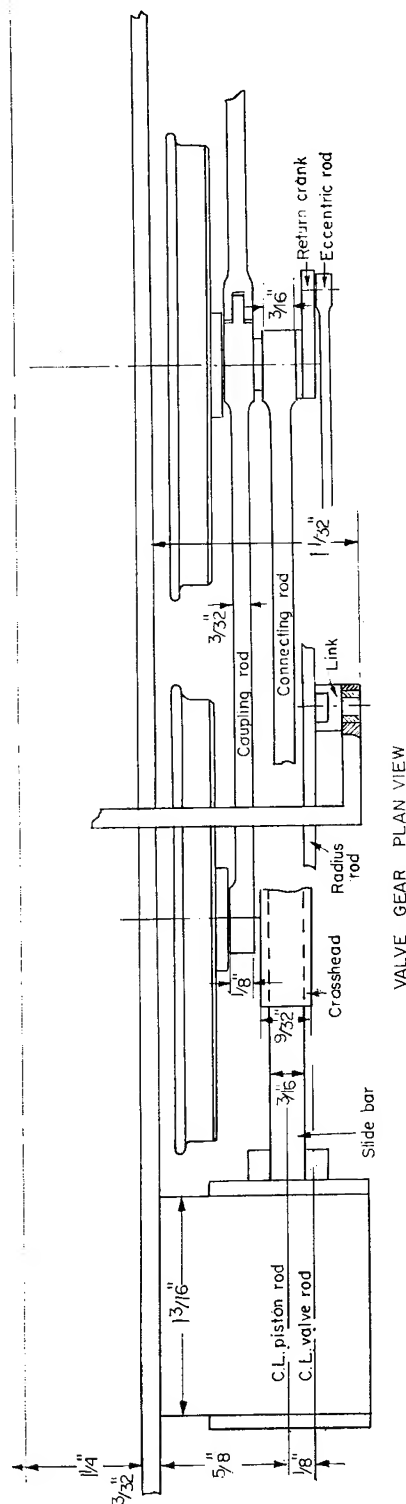
The coupling rods can now be finished off by filing, the flutes providing a useful guide to get the sections between the bosses to the correct width. Next, press home the bushes, putting the reamer through the driving bush again, and a No. 21 drill through the leading and trailing bushes, to allow for possible irregularities in the track.

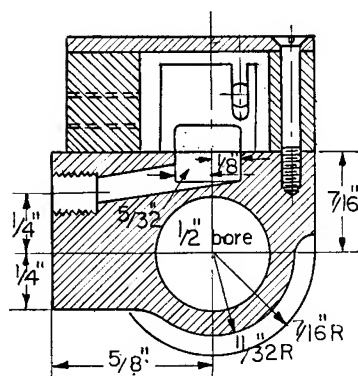
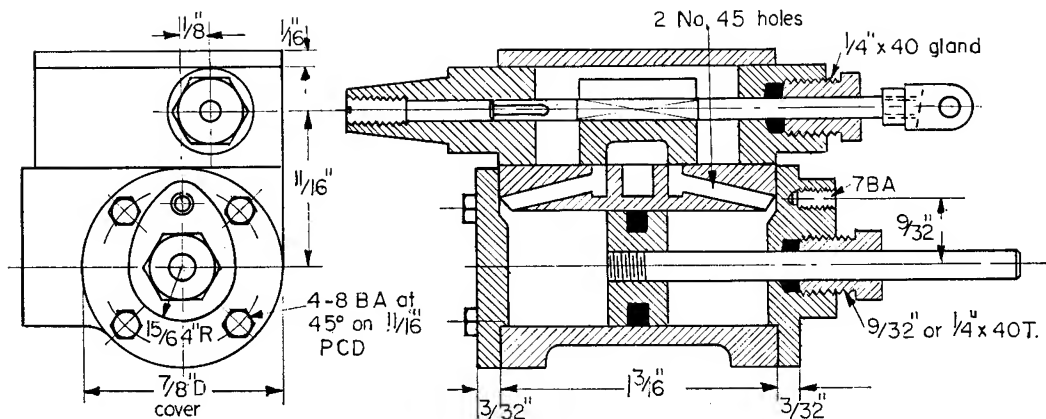
Cylinders

The cylinders are straightforward slide valve type in gunmetal. Starting with the blocks, clean up the outside surfaces all around, then chuck in the four-jaw and shift around until the bore is running true. If the bores are not cored out, mark out the required centre first, checking from the outside edge. Face one end, then bore out to 0.495 in. dia. finishing with a $\frac{1}{2}$ in. parallel reamer. If the builder has one of these with a Morse taper, put it into the tailstock, and slide the whole tailstock bodily along the bed, slowly in and out, with the lathe running at bottom speed, then a good finish should be obtained. But if no reamer is available, quite a good finish can generally be obtained if the boring tool is a rigid one, with a sharp cutting edge, and if this is put right through twice, without altering the cross-slide setting.

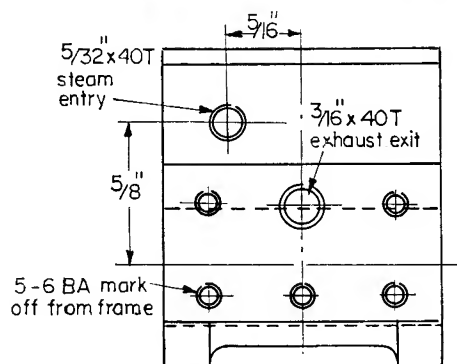
To face off the other end of the cylinder, turn up a temporary brass mandrel, of such a diameter that the block can be pushed home just tightly enough to withstand the cut of the facing tool. To machine the port face and bolting face, the four-jaw can again be used, but put pieces of soft metal between the chuck jaws and the finished cylinder ends, and set the block carefully with a try square.

The ports are best end-milled, the block being set up on an angle plate bolted to the vertical-slide, facing the headstock. The end-mill or slot drill will have to be $\frac{1}{16}$ in. dia., so run this at a good speed but be very modest with the cut, as it doesn't take much to break an end-mill of this size. The steam passages can be drilled by hand, or in the drilling machine, the block being set up in a vice at the required angle and "sighted", so that the drill

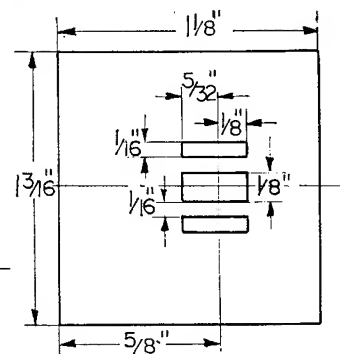




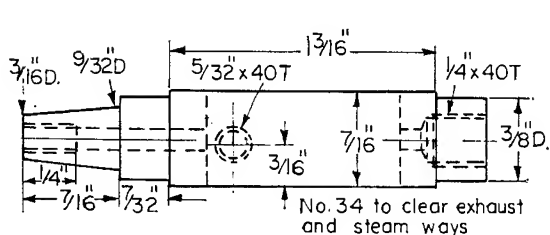
SECTION THROUGH VALVE



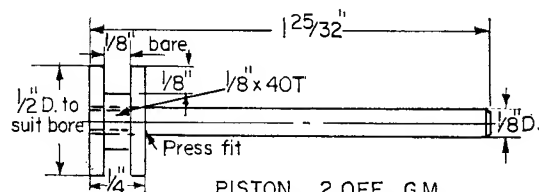
CYLINDER BOLTING FACE



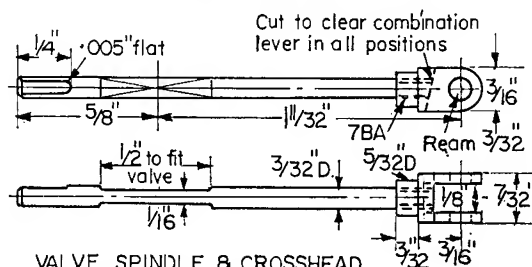
CYLINDER PORT FACE



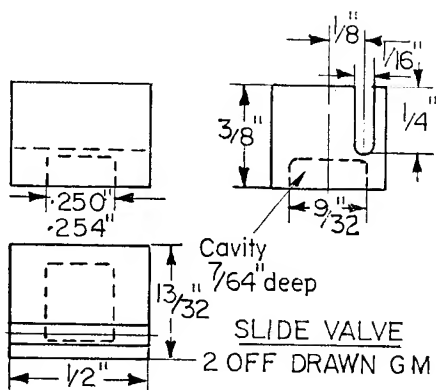
STEAM CHEST 2 OFF GM CASTING



PISTON 2 OFF GM
ROD STAINLESS STEEL



VALVE SPINDLE & CROSSHEAD
2 OFF SPINDLE STAINLESS STEEL
CROSSHEAD BMS CASE HARDENED



breaks through in the proper place. These passages consist of two No. 45 holes drilled close together. For the exhaust, drill and tap $\frac{1}{8}$ in. \times 40 t. centrally, at a point $\frac{1}{4}$ in. above the piston centre-line, then continue drilling but at an angle, so as to break into the exhaust port. This hole should be made as large as possible without fouling the threads of the $\frac{1}{8}$ in. diameter hole.

The pistons are made from drawn gunmetal or phosphor-bronze and are mounted on stainless steel piston rods. After mounting the rough-turned pistons on their rods, hold the rods in a collet chuck if available, or make up a little split collet.

The cylinder covers do not call for any special comment. The rear ones should be turned to fit the cylinder bore first, and drilled and reamed at this setting. They are then reversed and may be held in a simple split ring while the outside is finished off as far as is possible by turning, and the tapped hole for the stuffing box screwed with a pilot tap. Care should be taken with the 7 BA tapped hole for the slide bar, which is a simple single bar this time: there would hardly be room for a proper three-bar Gresley type. I always prefer to fit the rear covers to the block and then scribe the vertical centre-line for the slide bar hole, with the cylinder block laid on its bolting face on a surface plate. Both the piston and valve rod glands are turned from hexagon gunmetal, $\frac{9}{32}$ in. AF for the latter and $\frac{1}{16}$ in. AF for the former. If builders have screwing tackle for $\frac{9}{32}$ in. \times 40 t., this size is to be preferred for the piston rod gland, as it leaves more room for the packing.

Steam Chests

The steam chests will probably be cast with their bosses on. The four-jaw chuck can again be used to machine the bolting faces and the sides, again using strips of soft metal between chest and jaws as each surface is finished. Now chuck the steam chest by its longer (front) boss, and set the other

boss to run as true as possible, face it carefully, using a light cut, centre and then bring up the tailstock to support it while turning the outside, at the same time facing the end of the casting. Then remove the tailstock, drill and ream $\frac{3}{32}$ in. dia. and open out for the gland, which is tapped $\frac{1}{4}$ in. \times 40 t., with a pilot tap if possible.

Reverse the steam chest in the chuck, holding by the turned boss in the 3-jaw, and repeat the operations, but this time, tapping the end of the long boss 5 BA, for a plug, which will be fitted later. Drill and tap the hole for steam entry. The inside of the chest can be hand filed.

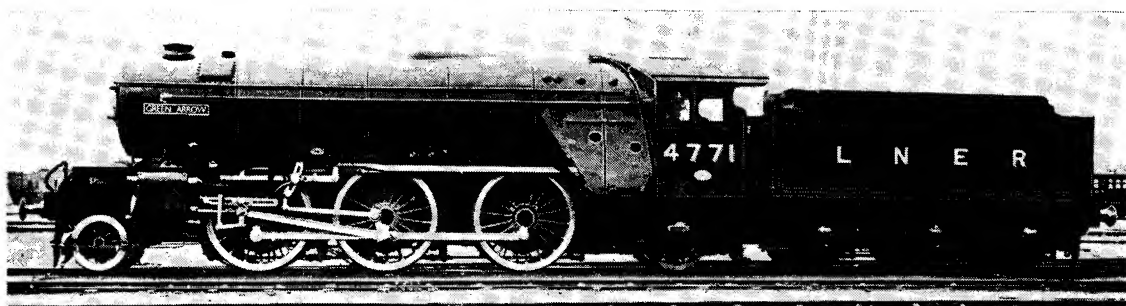
Make the covers next. These can be made from $\frac{1}{16}$ in. hard brass sheet or from dural. Mark out all the holes for the fixing screws, remembering that these have to clear both the tapped steam entry hole and the tapped exhaust hole. Drill these holes, then use the cover as a drilling jig for drilling corresponding holes in the steam chest. Now clamp the lot to the cylinder block, and run the drill right through, to make deep centres in the block. Dismantle, drill and tap the block, being careful not to go too deep.

The slide valves can be cut from a piece of drawn gunmetal. Mill out the recess first, using the $\frac{1}{16}$ in. end-mill or slot-drill again, then finish the outside by milling, filing, or turning, using the 4-jaw.

The $\frac{1}{16}$ in. slot for the valve spindle can be cut by clamping the valve in a machine vice, or between two pieces of steel angle held down on the cross-slide, with the valve packed up to the required height, a $\frac{1}{16}$ in. thick milling cutter being used between centres, or on a short arbor held in the three-jaw. Failing some machining operation, it is not difficult to produce this slot with that very useful hand tool, the Eclipse "4S". For the valve spindles, we need $\frac{3}{32}$ in. diameter stainless steel. One end is threaded 7 BA for a length of $\frac{3}{32}$ in., while a very shallow flat is filed on the front end, $\frac{1}{4}$ in. long. This is to prevent any possibility of condensed water being trapped in the front valve chest boss. Finally, file the $\frac{1}{2}$ in. long flat to drive the valve, taking great care here to get a nice fit with no end shake, but don't make the fit so good that the valve is prevented from seating properly on the port face.

To complete the assembly, make up the two valve crossheads from $\frac{3}{32}$ in. square b.m.s., or the nearest larger. Drill and ream the $\frac{3}{32}$ in. dia. cross hole first, then mill the $\frac{1}{4}$ in. slot for the combination lever. After this, cut the bar to length, mount in the four-jaw, and get the crosshead running true, then turn the boss, and drill and tap to suit the valve spindle; aim for a tight fit here, although the crosshead cannot of course become unscrewed in service, due to the method of driving the valve.

To be continued.



GREEN ARROW

A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2, designed and described by Martin Evans

Part V

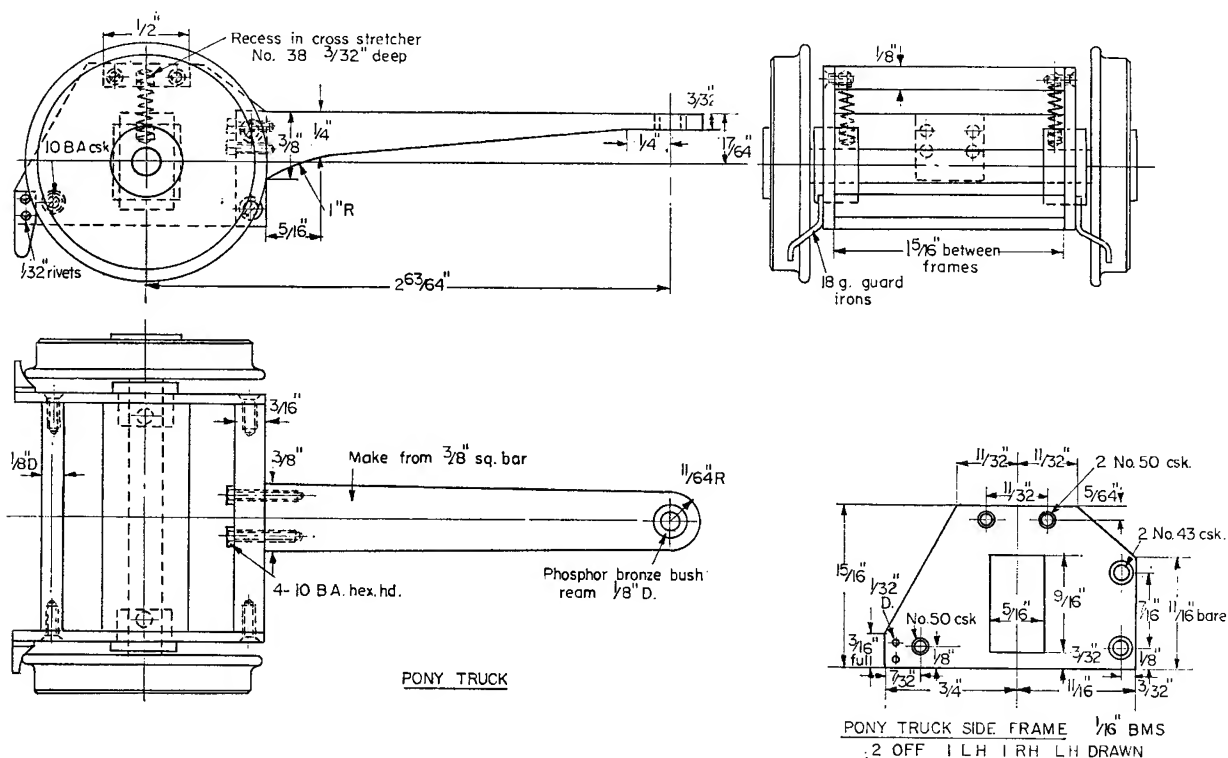
Continued from page 1177

BEFORE DEALING with the connecting rod and Walschaerts valve gear, we might first dispose of the pony truck.

I am not sure whether a proper side-control would be justified in 10 mm. scale, but it would be rather difficult to arrange in this size and its effec-

tiveness would depend a great deal on the sort of track the model would have to negotiate. But there is no reason why we should not have a simple form of independent springing for each wheel.

The full-size "Green Arrows" used coil springs, one on each side of each axlebox, plus the typical



Great Northern arrangement of swing links, a method of suspension which came in for a certain amount of criticism in later L.N.E.R. and B.R. days. This, if I remember rightly, was after a derailment near Hatfield, when the pony truck design was alleged to be responsible.

For our model, we can be content with a plain rubbing member, fixed to a rectangular bar stretcher across the engine frames, bearing on a similar flat stretcher across the pony truck frames. A single coil spring is then arranged above each axlebox, located by recesses in the top of the axlebox and in the underside of the stretcher.

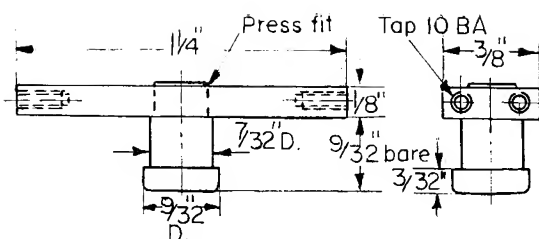
As it is necessary to bolt up this cross stretcher before assembling the wheels, and as the wheels cannot be "dropped" after they are pressed on their axles due to the absence of separate hornstays, the axlebox springs will have to be "sprung" into position afterwards.

Make the side frames first. They are cut from $\frac{1}{8}$ in. b.m.s., and are held apart at the correct spacing by the rectangular stretcher across the top, as previously mentioned, by a $\frac{1}{8}$ in. dia. round stretcher at the front, and by a rectangular stretcher of $\frac{1}{8}$ in. \times $\frac{1}{8}$ in. section at the rear, to which the radius arm is attached. The radius arm is cut from $\frac{3}{8}$ in. square b.m.s. It is slightly tapered in plan, and reduced in thickness at the pivot end for the bush, as shown.

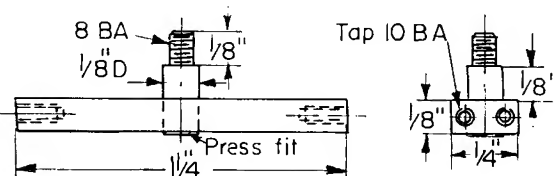
The axleboxes are milled from drawn gunmetal bar, $\frac{3}{8}$ in. \times $\frac{1}{4}$ in. section; they are single-flanged this time, so that they can be assembled from the outside. I have not specified the gauge or free length of the axlebox springs as I think it will be much easier to decide this by trial and error, after the engine has been completed; but they will have to be $\frac{3}{8}$ in. dia. and 24 s.w.g. could be tried for a start.

Guard irons can be bent up from 18 s.w.g. steel, and held on to the pony truck frames by two $\frac{1}{2}$ in. dia. rivets.

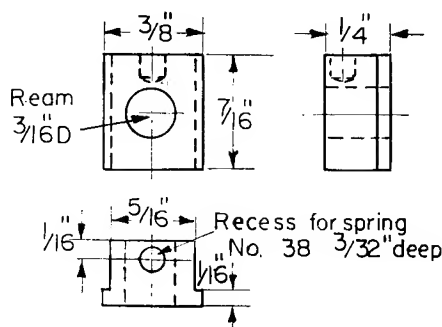
When fitting the completed pony truck to the engine, note that its pivot end goes above the pivot stretcher, an 8 BA nut and washer being put on afterwards.



MAIN FRAME STRETCHER FOR PONY TRUCK I OFF BMS



PIVOT STRETCHER FOR PONY TRUCK I OFF BMS PIN SILVER STEEL



PONY TRUCK AXLE BOX 2 OFF G M

I am glad to say that all necessary castings and materials for *Green Arrow* will be available shortly.

To be continued

"Peaveys"

SIR,—I have been following with some pleasure the account of Mr. W. J. Hughes in Canada. In his article in No. 3422, describing the curved hooked implement, he asked:—"is the name 'peaveys'?" If the exhibition was truly proto-typical then the sawyers should have been using a "cant hook". Their only requirement is to be able to turn or rotate the log in the carriage in order to square up the log into a balk before sawing it into boards or planks.

The business end of the handle, or more properly the helve of the cant hook, had usually an iron ring around it to prevent its splitting. On the other hand, the "peavey" (which got its name from the inventor, one John Peavey) had its business end terminated in a long

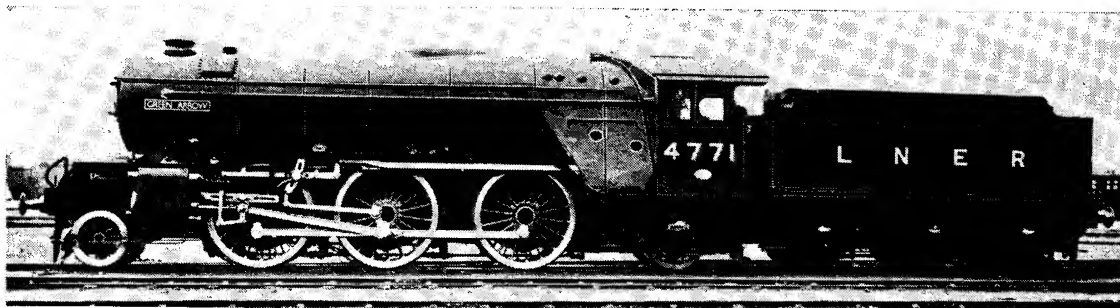
(perhaps 6 in. or so) sharpened steel point, extending well beyond the point of the hook.

The peavey was used by the rivermen or loggers, who conducted the "drive" or floating the logs from the assembly point in the cutting area down the streams and rivers to the mill ponds, to break up jams. This involved not only turning and twisting the logs, but pushing, pulling and prying the various logs to get the mess untangled and on its way again.

In addition to its intended use, rumour has it that the peavey was a most effective personal weapon in the brawls which sometimes broke out, when rival gangs of loggers got stirred up.

Sudbury, Mass., U.S.A.

S. W. HATHAWAY



GREEN ARROW

A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2, designed and described by Martin Evans

Part VI

Continued from page 1227

WE CAN NOW make a start on the motion work and valve gear. The first, and much the easiest item is the slide bar. As most readers will know, all the Gresley three-cylinder locomotives were fitted with his favourite three-slide bar and crosshead arrangement. He regarded this as a more efficient design than the two-bar or "alligator" type crosshead, favoured by most other railways at the time. There is no doubt that the Gresley design was considerably lighter than the "alligator" type, while the wide upper slide bar gave plenty of bearing surface for the crosshead for forward running.

I would like to have specified the correct Gresley type crosshead for our Gauge "1" *Green Arrow*, but having first drawn it out more or less to scale, I came to the conclusion that it would be beyond many builders; it would be real "watch-making". I have therefore substituted a single slide bar, made from rectangular silver steel, $\frac{1}{8}$ in. \times $\frac{3}{8}$ in., though the crosshead is a reasonable representation of the full-size job.

It is important that the thread on the end of the slide bar is exactly central with the bar, so set the material up in the four-jaw and adjust the jaws until the bar is running quite true. If no D.T.I. is available, use the lathe tool itself as a check.

For the crossheads, we will require mild steel about $\frac{3}{4}$ in. \times $\frac{1}{8}$ in. Mill or file this down to $\frac{3}{8}$ in. thick first, then reduce the lower part to a shade over $\frac{1}{2}$ in. wide. Mark out the boss centre and the gudgeon pin centre, then set up in the four-jaw until the boss centre is running true. Drill No. 31, and D-bit $\frac{1}{8}$ in. dia. to a depth of $\frac{1}{4}$ in. full. Now turn the outside of the piston rod boss as far as possible without cutting into the upper part of the

crosshead which works on the slide bar, i.e. $\frac{1}{4}$ in. from the outside of the boss.

Drill and ream the hole right through the crosshead for the gudgeon pin $\frac{1}{8}$ in. dia. To produce the rectangular hole for the slide bar, I think the best way is to mill a slot to the required depth, then cut out a small piece of mild steel to act as a top plate, which can be silver soldered in position. A $\frac{1}{8}$ in. dia. end-mill could be used to cut the slot, the partly made crosshead being held in the machine vice attached to the vertical-slide. Setting up may be a bit of a problem, and it will probably be asked how does one know when the slot has been cut deep enough? It is not possible to measure from the bottom of the slot to the centre of the gudgeon pin, nor can a length of silver steel be put through the gudgeon pin hole as the vice jaws will be in the way. The way to go about it is, therefore, to obtain a length of steel rod that is a really good fit in the piston rod boss. It may be found that if $\frac{1}{8}$ in. dia. silver steel is used, it will not be quite tight enough in the boss owing to the short length of the boss, so take a length of $\frac{3}{8}$ in. or $\frac{5}{8}$ in. dia. rod, and turn this down until the desired fit is obtained. Press this into the boss and apply one of the slide bars to the crosshead, pressing it well down into the slot. When the slot has been cut to the correct depth, the distance *between* the slide bar and the rod in the piston rod boss should be $\frac{1}{4}$ in. This can be checked with feelers.

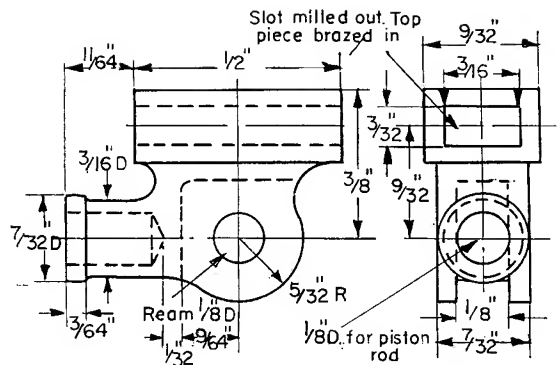
The next problem is how to hold the top plate in position while silver soldering it to the crosshead. Some careful filing will be required here. When a nice fit has been obtained, look for a strip of aluminium exactly $\frac{3}{8}$ in. thick, which can be put

into the slot so that the top plate can be pressed down on this. It will probably be necessary to file up a suitable piece of aluminium, in which case make it a little longer than the crosshead itself, and exactly the same section as the slide bar. ($\frac{3}{16}$ in. \times $\frac{3}{32}$ in.). If the top plate has been made a good fit, it will probably stay in place while the silver soldering is carried out, but a bit of rusty iron wire could be wrapped around the whole, if desired. To help the silver solder to run into the joints, file two shallow vee grooves as shown, and use the minimum amount of solder, otherwise it may run inside the slot.

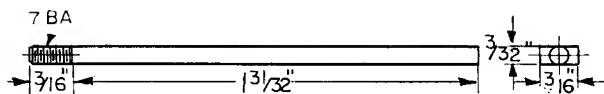
Finally, we have to hollow out the recess for the small end of the connecting rod. To do this, a $\frac{3}{32}$ in. dia. end-mill or slot-drill can be used, followed by one of $\frac{1}{8}$ in. dia. (If the $\frac{1}{8}$ in. end-mill is used straight away, the slot will probably come out a shade oversize.) It will be necessary to bring the end-mill in from the rear end first, then repeat from below, i.e. at 90 deg. to the first set-up. If this is not done, the recess will be left with a radius inside, which would foul the connecting rod. Fortunately, the crosshead can be held quite firmly by its rectangular upper part, while these two operations are carried out, but take very light cuts; it doesn't take much to break a $\frac{3}{32}$ in. end-mill!

Connecting Rods

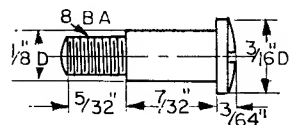
The connecting rods are cut from bright mild steel $\frac{1}{2}$ in. \times $\frac{1}{16}$ in. Drill and ream the holes first, after marking out, $\frac{1}{8}$ in. dia. for the gudgeon pin and $\frac{7}{32}$ in. dia. to take the big end bush, which is a separate turning in phosphor-bronze. File to shape in side elevation first, as for the coupling rods, but leave the part of the rod between the bearings about $\frac{1}{16}$ in. oversize at this stage, then tackle the fluting. It is not at all difficult to produce the tapered flute, which looks so much better than a parallel one. Use a $\frac{3}{32}$ in. wide Woodruffe cutter, hold the connecting rod down on the angle (as described for fluting the coupling rods), using a $\frac{1}{8}$ in. dia. close fitting screw or bolt in the small end, and a clamp at the big end. Then the rod can be swung slightly,



CROSSHEAD 2 OFF BMS.



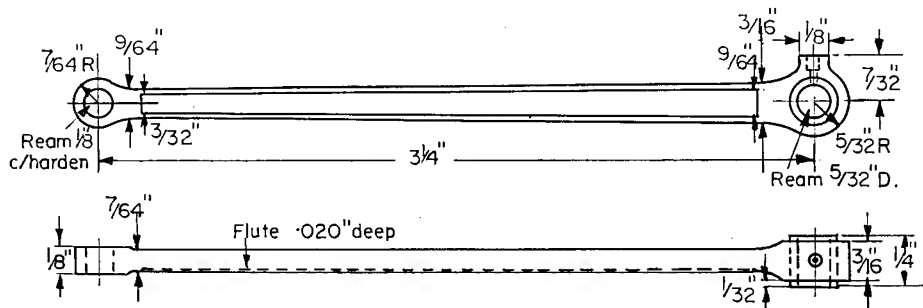
SLIDE BAR 2 OFF SILVER STEEL



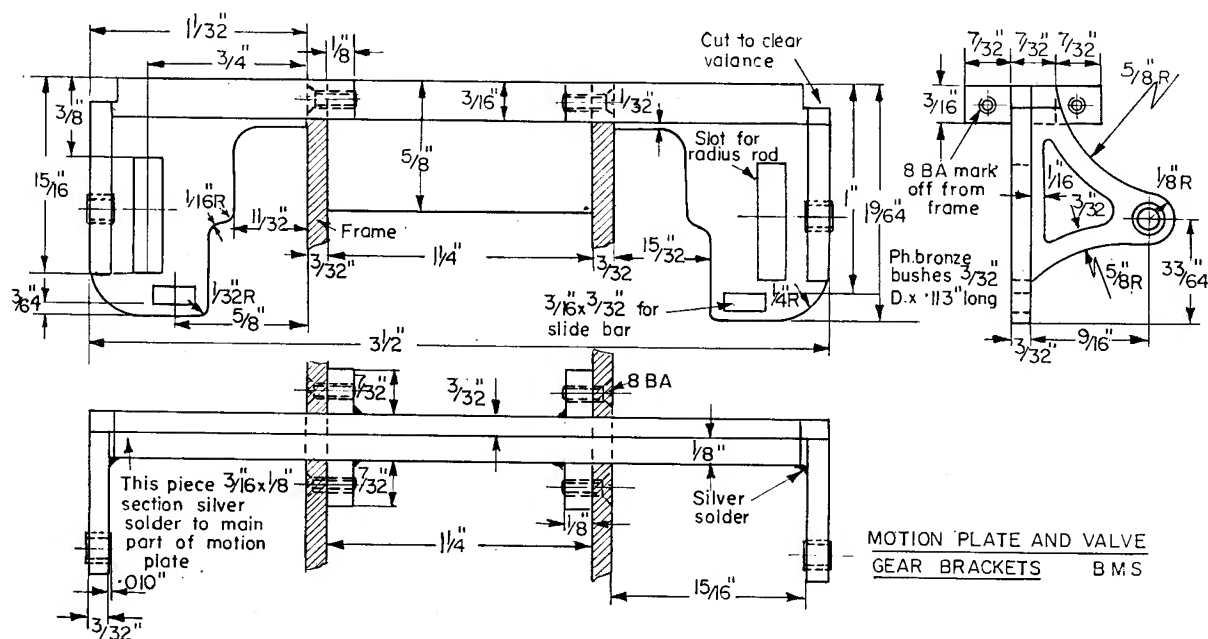
GUDGEON PIN 2 OFF SILVER STEEL

pivoting on the small end bolt, so that the flute is cut wider at the big end of the rod. It does not need to be deeper than about 20 thou.

The remainder of the rod should not present any difficulty. The big end bush should be made a press fit and a $\frac{3}{32}$ in. reamer put through after squeezing home. Unlike the coupling rods, there must be no slack between the big end bush and its crankpin.



CONNECTING ROD 2 OFF BMS BUSHES PH BRONZE



Motion plate

We now come to a rather complicated item, the combined motion plate and link bracket. The basis of this is a mild steel plate, measuring $3\frac{1}{2}$ in. wide \times $1\frac{3}{4}$ in. deep \times $\frac{3}{32}$ in. thick. A start should be made on this, marking it out very carefully, and taking special care too on the position of the rectangular slots to take the ends of the slide bars in relation to the underside which locates in the slots in the frames. Particular care should also be taken over the $1\frac{1}{4}$ in. wide part which lies between the frames. The answer is of course to keep "offering up" the motion plate to the locomotive frames, until it fits perfectly.

To stiffen the top of the motion plate, to give something for the link brackets to butt up against, and also to fill the frame slots (which it will be recalled are $\frac{3}{32}$ in. wide and $\frac{1}{16}$ in. deep) a length of steel strip of $\frac{3}{16}$ in. \times $\frac{1}{8}$ in. section is laid right across the rear top edge of the main plate, and is lightly riveted to it, pending silver soldering later on.

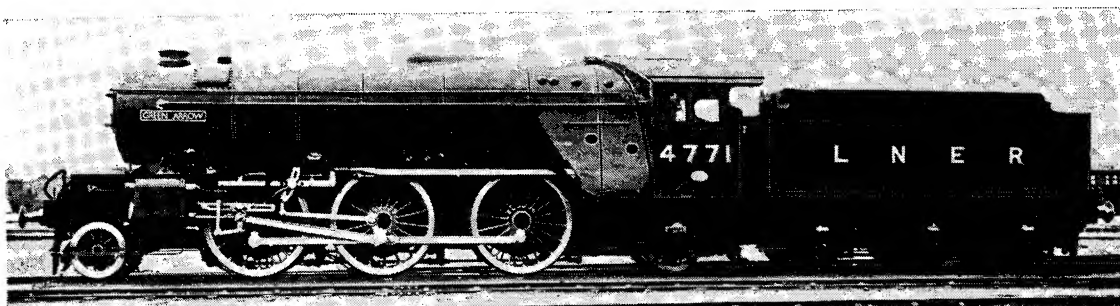
The link brackets are now cut out from $\frac{3}{32}$ in. b.m.s., drilled and reamed $\frac{3}{32}$ in. dia. for the phosphor-bronze bushes and shaped as shown in the drawing. The front edge of these must be absolutely square, otherwise when butted up against the motion plate, they will not stand out exactly at 90 deg., and this would upset the alignment of the whole valve gear, so file them a shade oversize on this edge, then put them in the four-jaw chuck and skim them to size.

Next, we require four little lugs, made from mild

steel, and measuring $\frac{3}{32}$ in. \times $\frac{1}{16}$ in. \times $\frac{1}{8}$ in. These are attached to each side of the motion plate, so that there will be one on each side of the slot in the main frames, for attachment of the whole affair to the frames. To hold these in their correct positions while silver soldering, a 12 BA steel screw or a tiny rivet could be put in, cross-wise. The link brackets could also be held in the same way, one or two 12 BA's being put in from the front, through clearing holes in the motion plate, into tapped holes in the link bracket.

When all the parts are held to the motion plate, try the whole affair in position in the frames, noting that the top edge of the motion plate should come flush with the top edge of the frames. At the same time, try the cylinders and slide bars in place, noting that the cylinders are aligned by means of the five No. 34 fixing holes, and also that the centre-line of the piston rod, continued right forward, should reach a point exactly $\frac{1}{4}$ in. above the bottom corner of the front buffer beam. If all is well, carefully remove the motion plate, so that nothing shifts, and silver solder all the joints. Finally, turn up the two link trunnion bushes, a press fit in the $\frac{3}{32}$ in. dia. holes in the link brackets. These should be 0.113 in. long, so as to protrude 10 thou each side of the bracket. To check that these bushes are in correct alignment, obtain a $3\frac{1}{2}$ in. straight length of $\frac{3}{32}$ in. dia. silver steel, and try it through the two link bushes, right across the locomotive.

The finished motion plate is held to the frames by four 8 BA screws as shown.



GREEN ARROW

A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2, designed and described by Martin Evans

Part VII

Continued from page 31

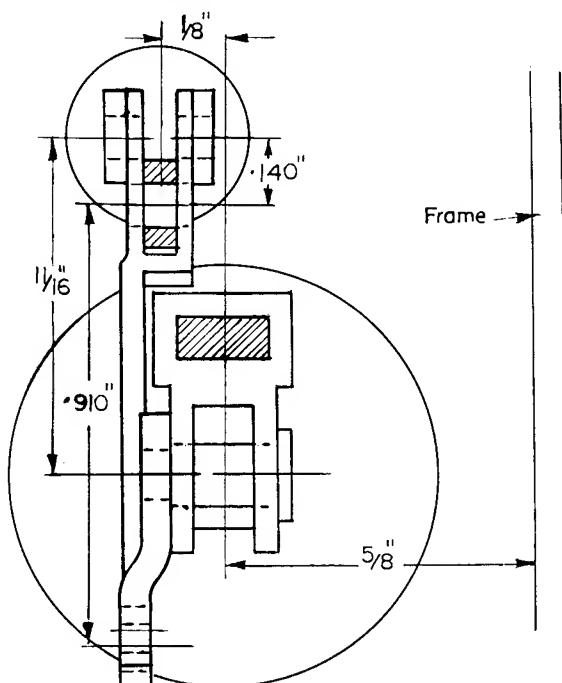
WE CAN NOW get down to some of the Walschaerts valve gear components, starting with the combination lever. It has not been at all easy to get enough clearance for this lever, especially as the change from inside steam admission to outside admission has brought the radius rod connection down below the valve crosshead. As the main crosshead is quite a bit over-scale in width, the combination lever has had to be offset considerably. I have drawn the end elevation of the crosshead assembly, which shows that there is only some 15 thou between the back of the combination lever and the upper part of the crosshead. However, as this lever is rather slender, it would be quite in order to bend it outwards very slightly if this clearance is regarded as inadequate.

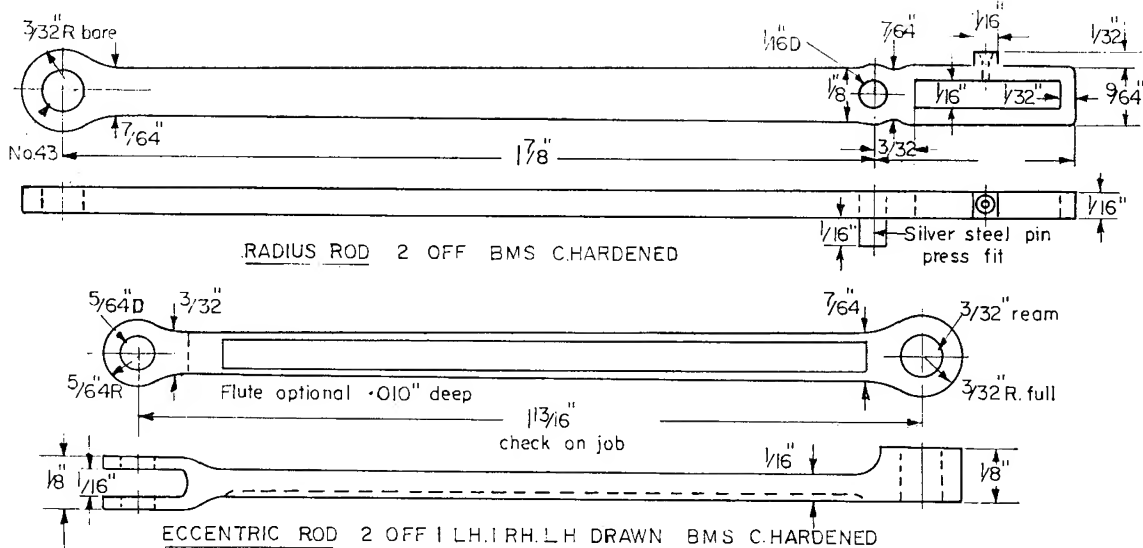
The combination levers can be made from $\frac{5}{32}$ in. square b.m.s., or the nearest larger. As usual with such components, we mark out the three bearings and the outline first, drill and ream all the holes $\frac{3}{32}$ in. dia. (If no reamer is available, drill No. 43 and finish with a D-bit.) Then clamp the job under the lathe tool-holder and mill the $\frac{1}{16}$ in. slot, using a slotting cutter on a short arbor or between centres. The slot should be continued until $\frac{3}{32}$ in. beyond the centre of the lower hole. At this set-up, the top end can be reduced to $\frac{1}{8}$ in. wide, by taking off $\frac{1}{32}$ in. from the outside edge. The remainder of the lever will have to be sawn and filed, as there is not enough metal left at this stage at the top end to enable the component to be gripped firmly. Do not case-harden just yet.

The drop-link is cut from $\frac{1}{16}$ in. thick b.m.s. Put the $\frac{3}{32}$ in. set in first, before marking out.

Drill both holes No. 44, then drill the bottom hole only No. 43 and ream $\frac{3}{32}$ in. dia. To ensure that this link does not become twisted on the gudgeon pin, a very small pin, about $\frac{3}{64}$ in. dia., should be put through at a suitable point in the body of the

Below: The combination lever assembly, to show clearances



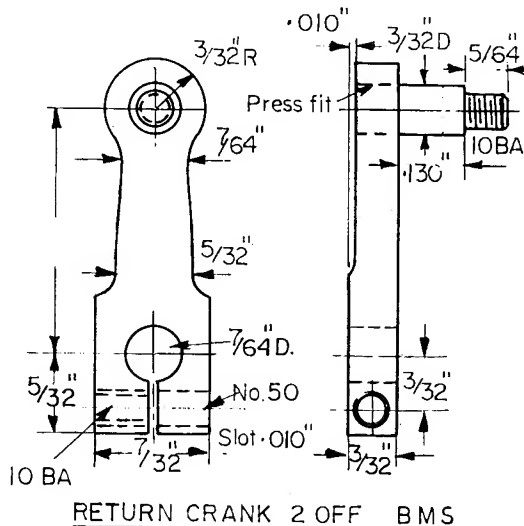
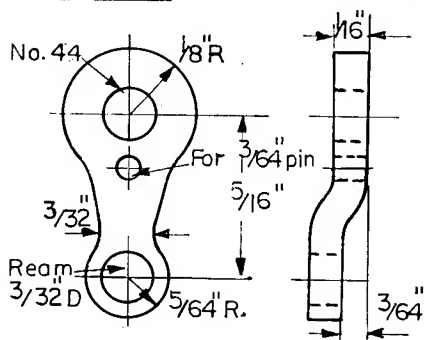
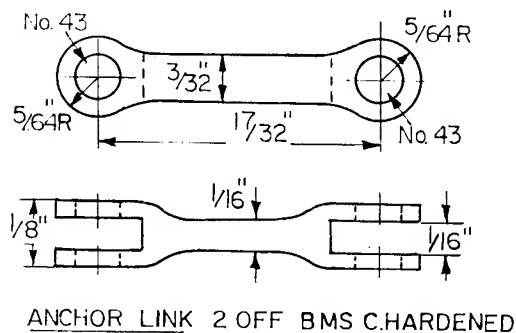


Note:—The dimension missing in the top drawing ($\frac{1}{16}$ in. hole to extreme right-hand end) should be $\frac{3}{16}$ in. bare

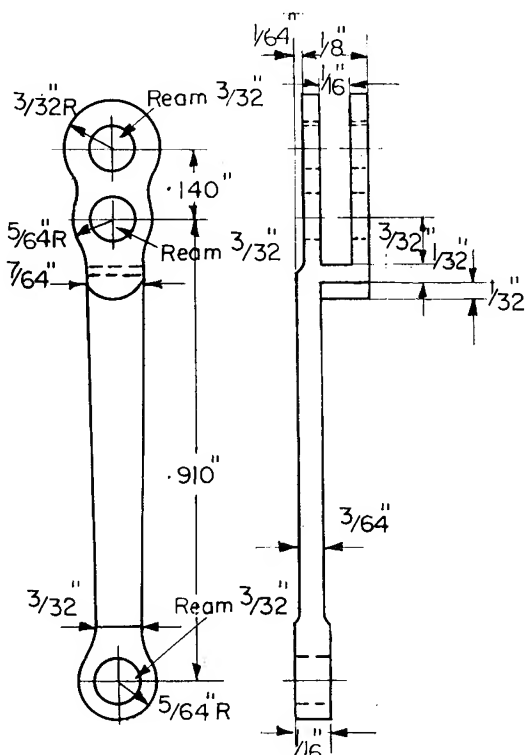
crosshead, below the gudgeon pin. When the case-hardening is carried out, at a later stage, the bottom hole only should be hardened.

For the anchor link, $\frac{5}{32}$ in. square b.m.s. will

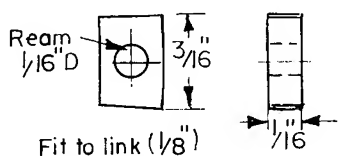
again come in handy. Start by reducing one side to bring the section to $\frac{5}{32}$ in. \times $\frac{1}{8}$ in. Mark out and drill the two holes No. 43. The $\frac{1}{16}$ in. slots can be milled as described for the combination lever.



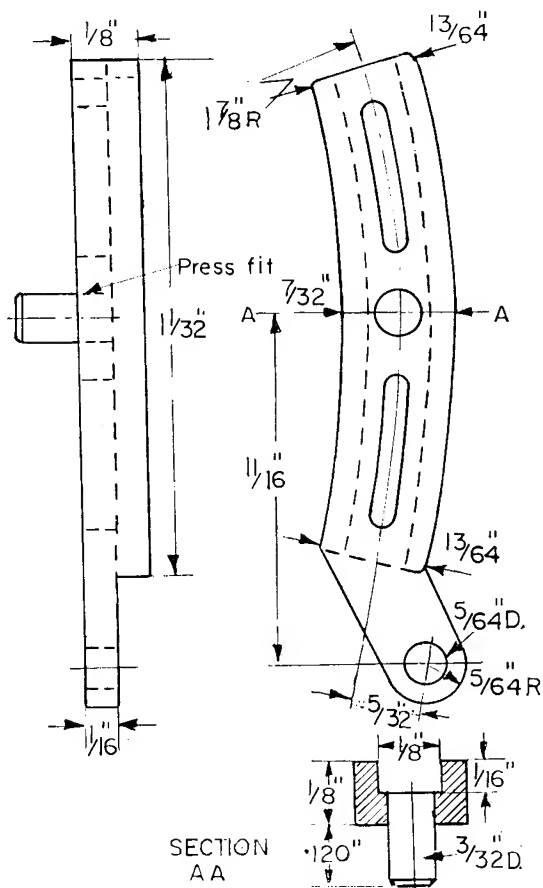
Note:—The throw of the return crank shown above should be 0.495 in.



COMBINATION LEVER 2 OFF
B M S C. HARDENED



DIE BLOCK SILVER STEEL
HARDENED



EXPANSION LINK 2 OFF 1 LH 1 RH
LH DRAWN B M S C. HARDENED

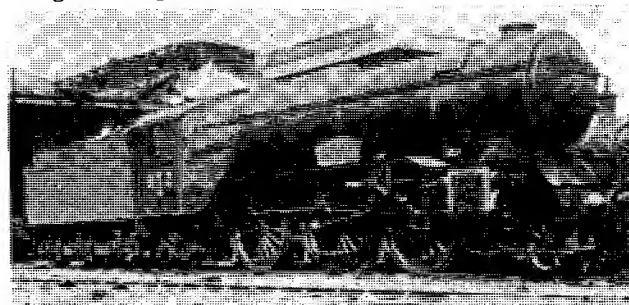
Complete the anchor link by sawing and filing to shape.

The next items, the radius rods, are a little more elaborate. $\frac{1}{8}$ in. \times $\frac{1}{16}$ in. b.m.s. will be required. Mark out and drill the holes, and drill two holes at the ends of the slot for the lifting gear. A $\frac{1}{16}$ in. Woodruff cutter could be used here, though it is not difficult to saw this out, using a jeweller's saw and No. 00 blades, finishing with a thin flat needle file. The pin to carry the die-block is $\frac{1}{16}$ in. silver-steel, and is made a press fit in the rod.

Expansion Links

It is hardly practicable to make the expansion link to the correct Gresley design, which would involve three separate plates to each link, so the one-piece

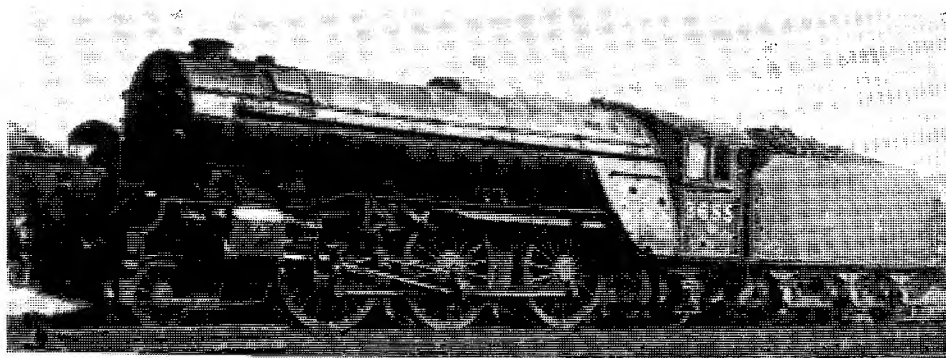
open sided type has been adopted. As the curved slot, which is on the inside of the link, is open-ended, the die-block being restrained only by the lifting gear, the slot can be cut by a parting tool, using the faceplate.



No. 3655 in
post-war livery.

Below left:

No. 872 one of
the named
engines—
"King's Own
Yorkshire Light
Infantry"



A suitable length of $\frac{1}{8}$ in. mild steel can be bolted or soldered to a larger piece of the same material, any bolts used being arranged clear of the path of the parting tool. Before tightening the bolts holding the backing plate to the faceplate, shift the plate around until the parting tool, which is arranged cross-wise under the tool-holder at a distance out equal to $1\frac{3}{8}$ in., cuts in the centre of the blank. The parting tool must be really sharp and not too wide, $\frac{1}{16}$ in. is enough, and it should have plenty of top rake and a fair amount of front clearance and side clearance on both sides. Use low speed and plenty of cutting oil for a good finish. The die-blocks can also be made using the parting tool in a similar manner.

After a nice curved slot has been produced to a depth of $\frac{1}{16}$ in. the blank can be unbolted, the rest of the link marked out and the hole for the trunnion pin drilled No. 43. The narrow curved slots are only to improve the appearance and have no actual function; but without them, the link will not look much. They should be about $\frac{3}{4}$ in. wide, and can be cut by drilling small holes at each end and using the "00" metal blade in the jeweller's saw. The finished links, after the die-blocks have been satisfactorily completed, can be case-hardened right away, but keep the case-hardening compound away from the trunnion pin hole as far as possible, as this should not be hardened. The die-blocks can be hardened right out by heating to red and dropping in oil.

The return cranks should be made next. For these, we will require $\frac{1}{4}$ in. \times $\frac{3}{32}$ in. b.m.s. The hole to carry the return crankpin is drilled No. 43, and that for the main crankpin $\frac{7}{16}$ in., though the latter should be opened out gradually so as to get a nice tight push fit on the crankpin. Cross-drill No. 54, slit into the $\frac{7}{16}$ in. dia. hole, then tap 10 BA half-way through, drilling the remainder No. 50. The back of the return cranks should be relieved 10 thou, as shown. The return crankpin is made from $\frac{3}{32}$ in. dia. silver-steel, a press fit into the crank, the outer end being turned down and threaded 10 BA for a length of $\frac{5}{16}$ in.

Eccentric Rods

It is not a bad plan to make up a dummy extendable eccentric rod, and use this for valve setting. Alternately, leave the eccentric rod until valve setting has been completed, the exact length of this rod being found by the well-known "dividers" method (which I will describe in the next issue). But I will just run over the making of this rod. It can either be made from $\frac{1}{8}$ in. thick b.m.s., the offset being produced by bending the rod, or it may be made from $\frac{1}{16}$ in. thick material, this being first milled or filed down to $\frac{5}{32}$ in. thick. Drill the small end $\frac{5}{16}$ in. dia., to suit the expansion link "tail", and drill and ream the big end $\frac{3}{16}$ in. dia., then slot the small end with a $\frac{1}{16}$ in. milling cutter. If the flute is required, do not thin the rod out at this stage, but use a Woodruff cutter to remove the unwanted $\frac{1}{32}$ in. from the outer side, then cut the flute about 10 thou deep, using the same methods described for the connecting rods. Now reverse the rod, milling down to $\frac{1}{16}$ in. thick between the bosses, finally completing by filing. Both ends should be case-hardened later on.

Reach Rod

I would now advise that a temporary reach rod and cab reverser be made up; just enough to enable the valve gear to be tested for working clearances. The exact shape of the reach rod should be left until the boiler has been made, while the temporary rod can be cut from b.m.s. of $\frac{1}{16}$ in. \times $\frac{3}{32}$ in. section. It can be clamped to the trailing frames with a small toolmaker's clamp for the present.

To be continued

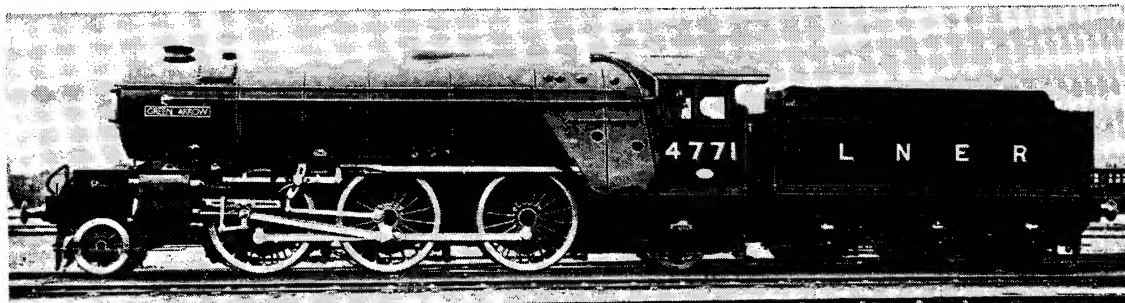
GREEN ARROW DRAWINGS

The following full-size drawings are now available, price 50p each:—

LO.939.

Sheet 1.—General arrangement and valve gear details.

Sheet 2.—Frames, wheels, axles, axelboxes, coupling rods, cylinders and feed pump.



GREEN ARROW

**A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2,
designed and described by Martin Evans**

Part VIII

Continued from page 85

TO COMPLETE the valve gear for *Green Arrow*, we will require the weighshaft, the two lifting arms and the single reversing arm, to which the reach rod is connected. The weighshaft is a length of $\frac{3}{8}$ in. dia. b.m.s., turned down to 0.1255 in. dia. at the ends, for a length of $\frac{3}{8}$ in. If the lifting arms are carefully reamed, and the 0.1255 in. dimension adhered to, the arms should be a nice tight push fit on the weighshaft, which is what we want.

The lifting arms are cut from $\frac{1}{8}$ in. square b.m.s., one side being filed or milled down by $\frac{1}{32}$ in. We will require rather a deep slot in these items, $\frac{1}{8}$ in. full wide, so mark out the two arms on a piece of the material about 4 in. long (one on each end). Then we shall have something to hold by, while running in the milling cutter. Radius the bottom of the slot as shown on the drawings, as we need all the clearance we can get here. Drill $\frac{3}{16}$ in. or No. 56, half-way through the larger boss, so that the arms can be pinned to the weighshaft at a later stage.

The reversing arm is also made from $\frac{1}{8}$ in. square b.m.s. This may sound a little hefty for a Gauge I locomotive, but as can be seen from the drawing, it is thinned out quite a lot between the pin holes. It does however allow for a substantial reach rod, which will be made from $\frac{3}{16}$ in. \times $\frac{3}{8}$ in. section material, and in any case, will be partly hidden by the running board on the finished locomotive. Ream the larger hole $\frac{1}{8}$ in. dia. very carefully, as this arm should be a nice close fit on the weighshaft.

Trailing wheels

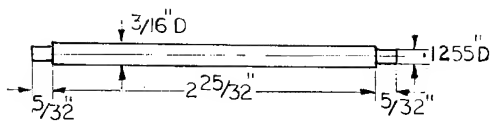
Looking at the official drawings of the *Green*

Arrow, I was surprised to find that there was only an inch difference in the diameters of the trailing wheels and the tender wheels, though the former had only ten spokes, while the latter had twelve. We can hardly expect the suppliers of the castings to make up separate patterns for both types of wheel, so I hope builders will be satisfied with one standard wheel, with ten spokes! The difference will not be easy to detect anyway, once the wheels are behind their frames!

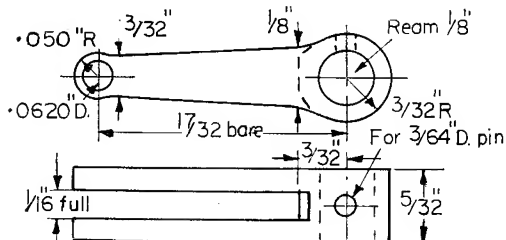
The dimensions of the trailing and tender wheels are again to B.R.M.S.B. standards, apart from the boss, which protrudes slightly more. These wheels can now be turned up, as described for the driving and pony wheels, and we might as well make the four axles, though note that the journals on the tender axles are a little longer than the trailing, as we do not require quite so much end play on the tender axles.

To be correct to prototype, the trailing axleboxes should be of the radial "Cartazzi" type, as used on all the Gresley "Pacifics", as well as on the *Green Arrows*, but this type is best left to the experts. In fact, the Cartazzi axlebox is not strictly a radial type, the sides of the axleboxes are machined off at an angle, i.e. not exactly at 90 deg. to the frames, and the horns are machined to suit, so the axleboxes should not be made too close a fit if the engine is to be reasonably flexible on curves.

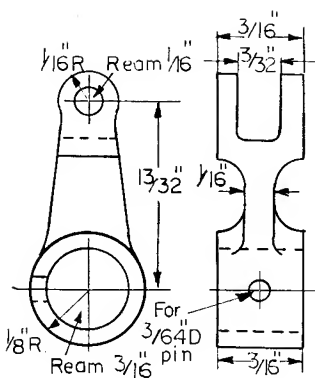
The trailing horns are riveted to the frames so that the axleboxes bear partly against the frames and partly against the horns. The spring leaves can be made of spring steel about $\frac{1}{4}$ in. thick, or hard phosphor-bronze may be used. But note that if either of these metals is adopted, there will



WEIGHSHAFT 1 OFF BMS



LIFTING ARM 2 OFF BMS

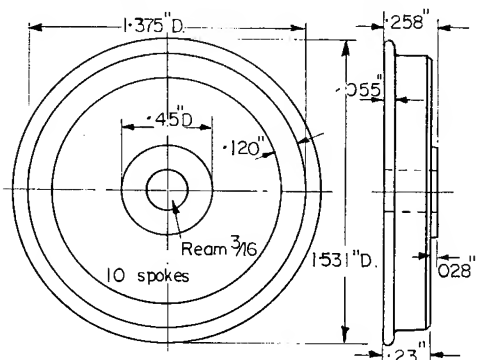


REVERSING ARM 1 OFF BMS

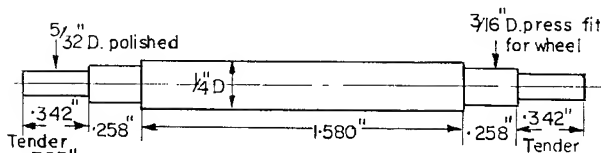
FURTHER
VALVE
GEAR
COMPONENTS

have to be a small compression spring inserted between the springs and the top of the axlebox, both of which can be drilled so that the coil spring enters into them to the extent of about 3/32 in. The drawings show how to arrange for the leaf

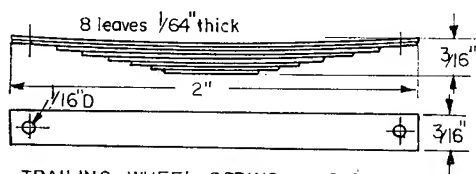
springs to actually do the job, but in this case, they will have to be made of tufnol, which should first be heat treated as described recently by Mr. H. A. Taylor, and also myself in dealing with the *Princess of Wales* springing. If the leaf springs made entirely



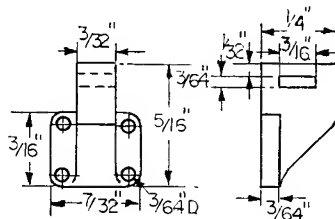
TRAILING AND TENDER WHEELS 8 OFF C L



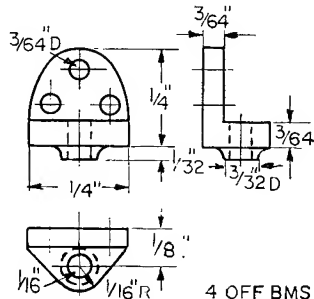
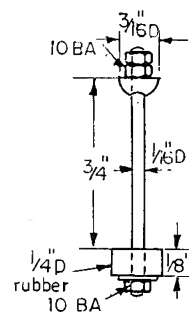
TRAILING AND TENDER AXLE 4 OFF BMS



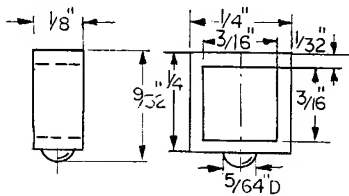
TRAILING WHEEL SPRING 2 OFF



SPRING GUIDE 4 OFF BMS



SPRING SUPPORT BRACKET 4 OFF BMS



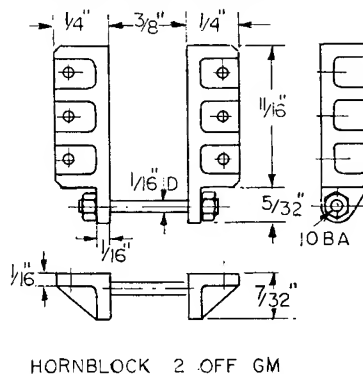
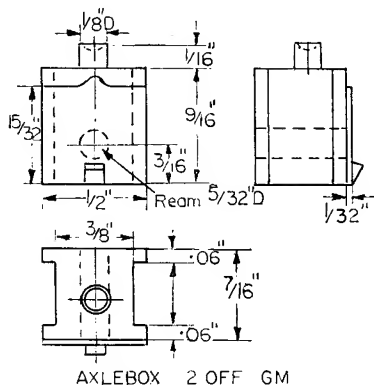
SPRING BUCKLE 2 OFF BMS

of tufnol are still found too stiff in practice, the leaves, except for the top and bottom ones, can be "weakened" by cutting oblong slots out of them, as is often done in larger gauge work.

I am often asked why I never specify the exact gauge of wire, or exact thickness of leaf to use for locomotive springs. True, these values can be calculated without any great difficulty, but they are still quite useless unless one knows the weight of the finished engine in working order, and to work this out from first principles would be an enormous

bit of "trial and error" until the best results are achieved.

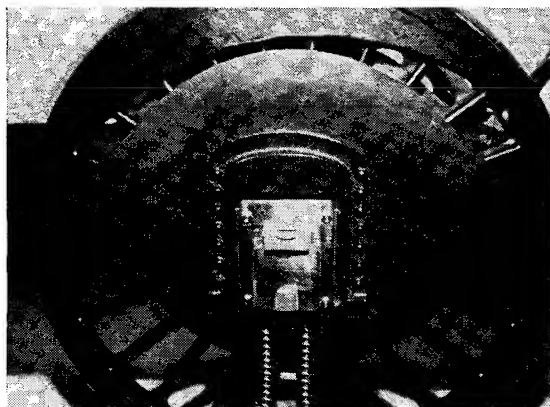
My next article will deal with the boilers. There will be two different designs, one for coal firing and the other for bottled gas, but the only real difference will be in the arrangement of the tubes, the coal-fired version having one superheater flue and five or six (not decided at the time of writing these notes!) $\frac{3}{8}$ in. dia. tubes, while the bottled gas version will have the same superheater flue, but as many $\frac{1}{4}$ in. dia. tubes as can reasonably be got in. There will



job single-handed. Even then, unless the builder has had a great deal of practice not only in building locomotives of this particular scale, but in running them, it is impossible to decide beforehand what proportion of the total weight of the engine to put on each axle! As I am working in the dark to some extent therefore, it is far better to finish the engine right out before starting to think about the exact specification for the springs, and then do a

be no thermic syphon, which in this small scale would almost certainly lead to ebullition, and no combustion chamber, which is really a quite unnecessary complication in so small a boiler. In fact, the *Green Arrow* boiler will be a very simple one to make, and the necessary silver soldering will not call for anything very frightening in the way of brazing torches!

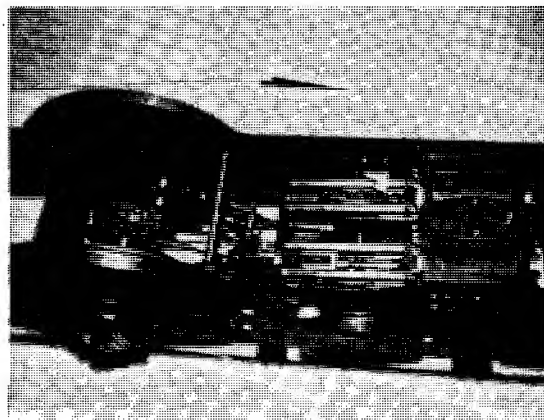
To be continued

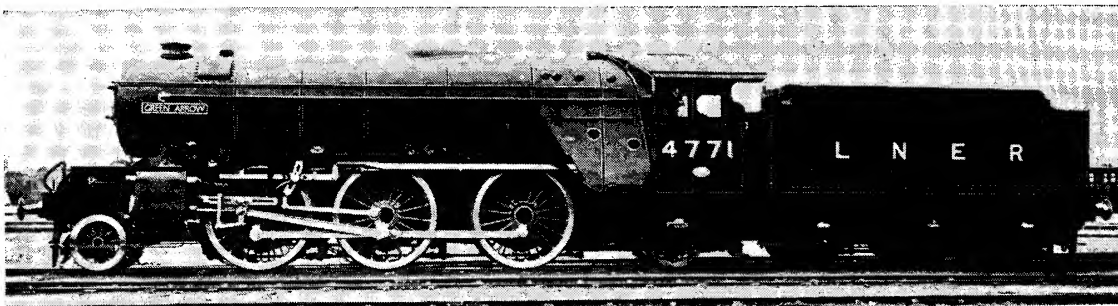


Outside axleboxes and horns. The work of Mr. G. E. Thornton.

A "Princess of Wales" in British Columbia

Below: The motion work.





GREEN ARROW

A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2, designed and described by Martin Evans

Part IX

Continued from page 137

THE COAL-FIRED BOILER for the Gauge I *Green Arrow* is a straightforward wide-firebox, round-top type, originated by Wootten in the U.S.A. It is one of the easiest of the locomotive type boilers to build. The very wide firebox makes it easy to get at the nuts on the inside, when staying.

The tubes may look rather long in relation to the boiler as a whole, but in relation to their diameter, the proportion is actually quite normal. They are $7\frac{1}{2}$ in. long, which is a good deal shorter than many $\frac{3}{8}$ in. dia. tubes used in the larger $2\frac{1}{2}$ and $3\frac{1}{2}$ in. gauge locomotives.

Only one superheater flue can be got in, in a boiler of this scale, but this should be adequate, especially if a radiant-heat firebox type of superheater is to be used. Those who do not believe in too high a superheat can adopt the traditional "spearhead", ending just short of the firebox tubeplate.

Before starting on the actual construction, a word about heating apparatus. Those having Sievert or Primus propane equipment will find that burner No. 2943 (the largest but one in the range) is almost too powerful for this size of boiler. The next smaller burner, No. 2942, would probably do the job without any coke packing being necessary, while No. 2941 would be large enough given careful coke packing.

A good paraffin blowlamp, or petrol blowlamp of one or two pint capacity could also be used, though far be it from me to recommend such fearsome machines! A gas/air blowpipe of $\frac{3}{8}$ in. bore would tackle the job with the greatest of ease.

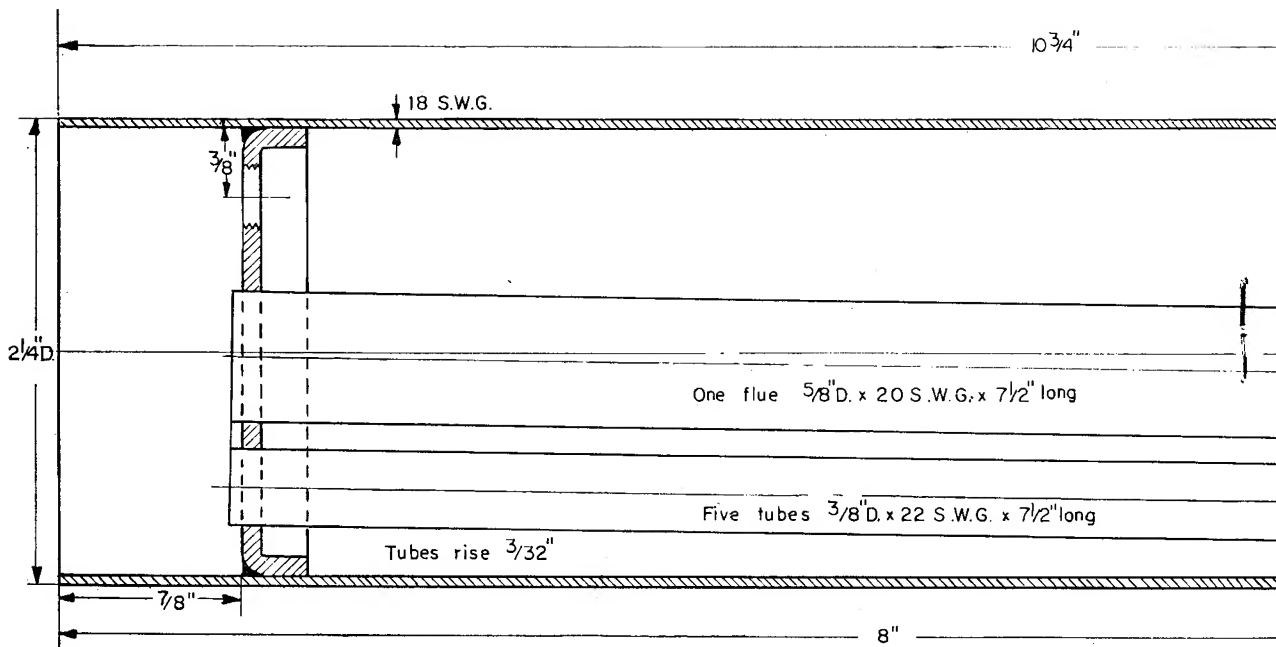
Those who have not brazed up a locomotive

boiler before would be well advised to make up a simple brazing hearth or stand; one hears queer tales of model engineers brazing boilers on a slab of asbestos on their work-bench—a practice to be greatly discouraged! As for the pickling operations, I have found an ordinary commercial rubber bucket an ideal pickle "tank" for small boilers. These buckets are much stronger and thicker in the walls than the rather similar plastic household buckets. As for the acid, the sulphuric acid of the same strength as found in a car battery is about right for our purposes without any further dilution, but it will take the acid from about three car batteries of average size to give us enough depth of acid in our rubber bucket. If purchasing acid from the chemist, don't forget to ask for the *commercial* concentrated acid, and this is added to the water (NEVER the other way round) in the proportion of about 1 acid to 10 water.

There are three distinct ways of making the outer wrapper-cum-barrel.

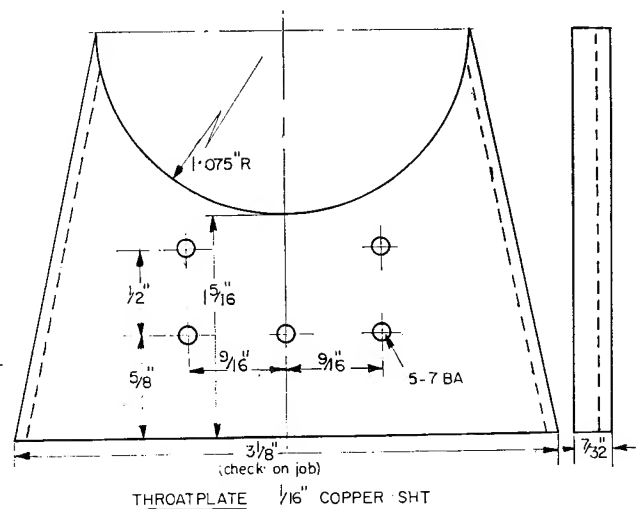
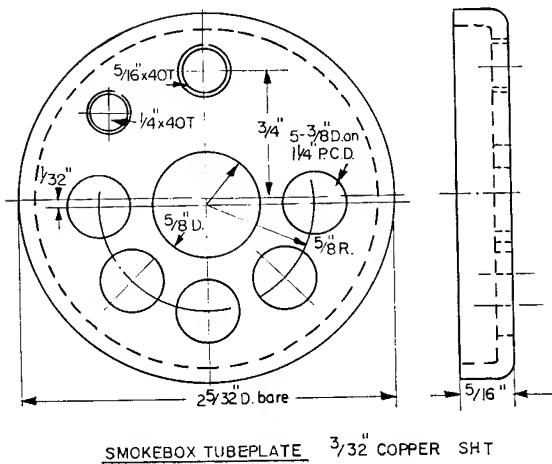
1. Use a seamless tube the full length of the boiler, cut and open out for the firebox wrapper and add short extensions to give the required depth to the firebox.
2. Use a seamless tube for the barrel proper only, then use a separate firebox wrapper cut from sheet, the join being made by a so-called "piston-ring" joint.
3. Bend up the whole affair, barrel and wrapper, from flat sheet.

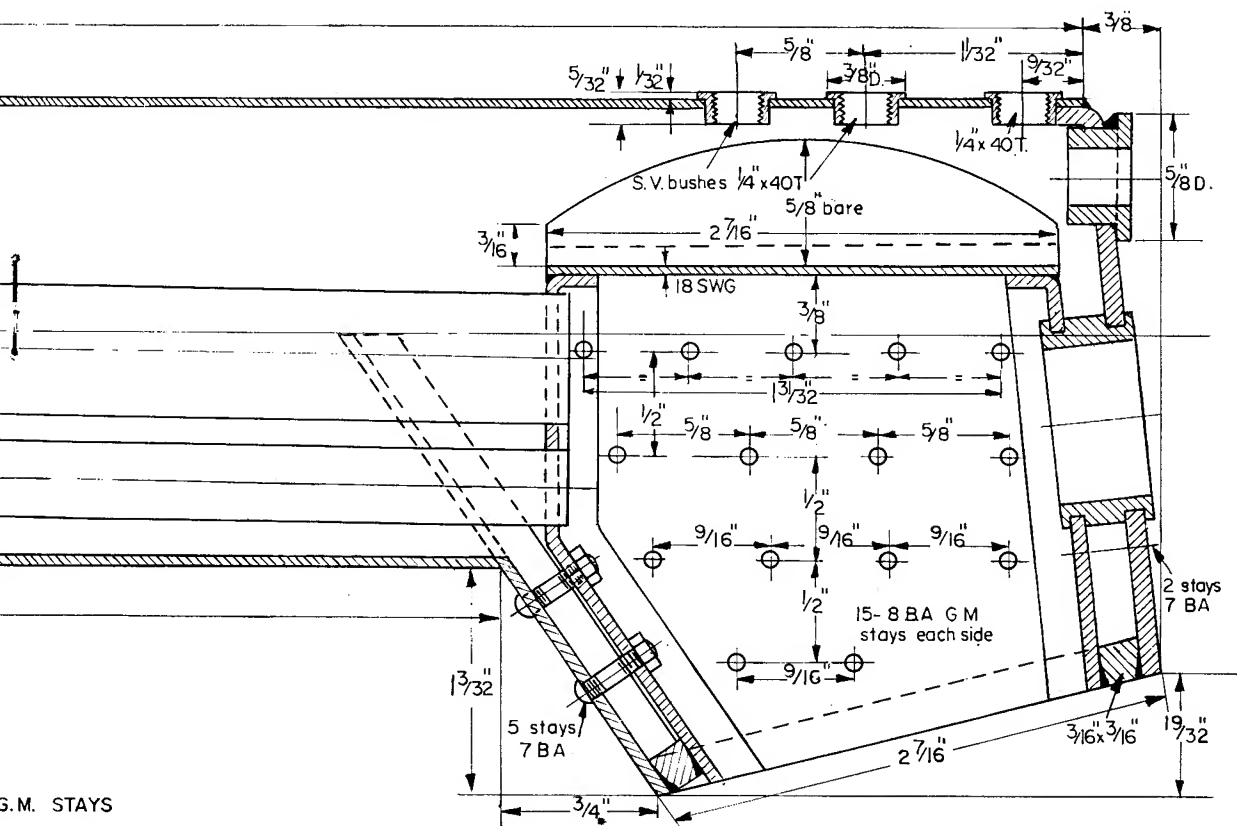
The snag of method No. 3 will be found at the sloping throatplate. Method No. 2 calls for some careful cutting of the rear end of the barrel, so as to



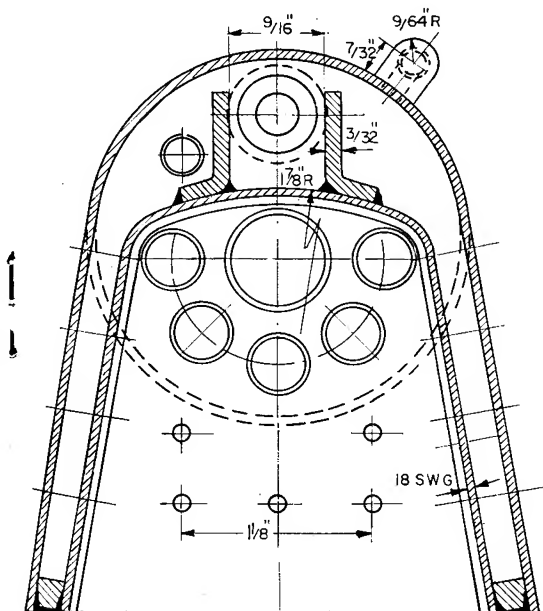
Working pressure 100 p.s.i.
 Hydraulic test pressure 200 p.s.i.
 All joints silver soldered

BOILER FOR COAL FIRING LOCOMOTIVE COPPER WITH G.M.

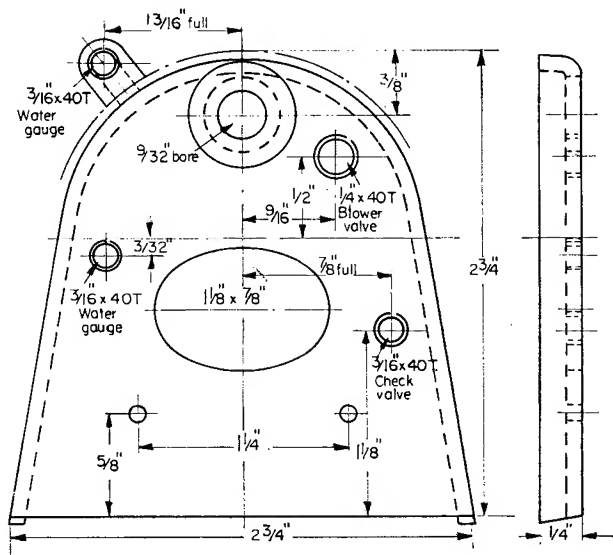




G.M. STAYS



SECTION OF FIREBOX TUBEPLATE LOOKING TO REAR



BACKHEAD 3/32" COPPER SHT

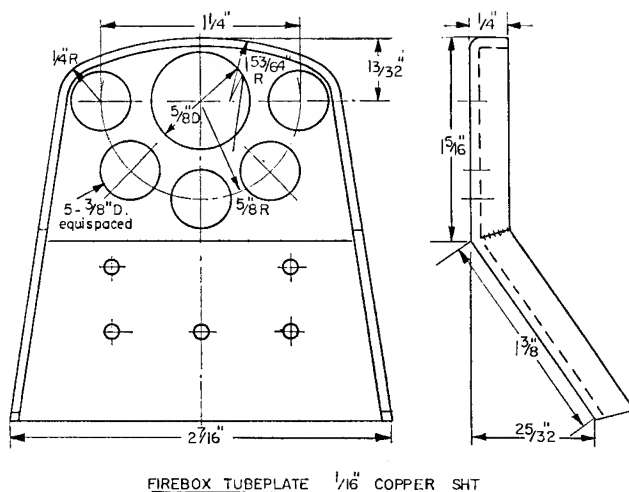
"fill in" at the throatplate. A drawback here also is the thickness of the "piston ring" below the tubes.

I much prefer the first method, especially as the barrel tube can be used to "telescope" nicely into the smokebox, which will be made from $2\frac{3}{8}$ in. \times $\frac{1}{8}$ in. seamless brass tube, which is a commercial size.

For the first method, then, select a nice clean truly circular length of seamless copper tube, $2\frac{1}{4}$ in. O.D. \times 18 s.w.g., $11\frac{1}{2}$ in. long. Turn up a hardwood disc a close fit in one end, and fit a bolt with a centre in it to this, so that one end of the tube can be supported in the lathe, the other end of course being held by the three-jaw chuck. Some builders may find that they have a fixed steady of large enough capacity to take this tube, so they won't need to bother with the wood plug. Which reminds me, Arnold Throp of Dore Engineering had two most useful lathe steadies of very large capacity at the recent *Model Engineer Exhibition* specially designed to support large diameter tubes such as we use for the barrels of the larger locomotives.

Finish machine the front end of the barrel now, then saw and file the rear end so as to bring the length on the top centre-line to $10\frac{1}{4}$ in. To ensure making the saw cuts correctly for opening out the wrapper part, it is a good plan to lightly glue some thin cardboard over the tube at the rear end, then open this out to check the dimensions of the wrapper. It is necessary to extend the wrapper on both sides to obtain the full depth of firebox required. Alternately, off-set the longitudinal saw-cut, so that the wrapper can be made the full depth on one side, leaving one piece only to be extended. I used this method on my last 5 in. gauge locomotive boiler; it worked out alright, but calls for careful measuring before cutting. That is why I strongly recommend the cardboard process first. Cardboard is a little cheaper than copper!

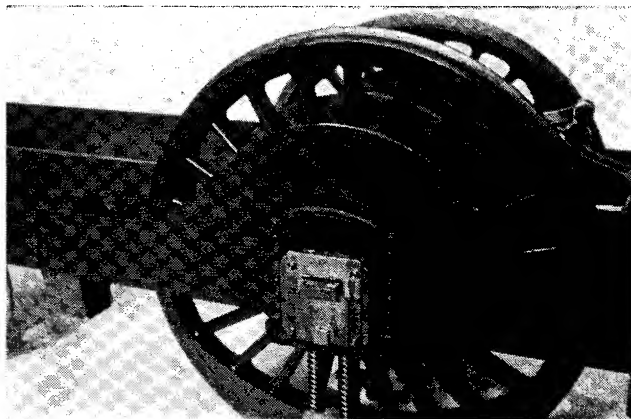
The extending of the bottom edge (or edges) of the wrapper has been described in M.E. many times. Using 18 s.w.g. material, a "coppersmith's joint" is not at all difficult, and this makes the staying of the firebox later on a much cleaner operation; but for those who fight shy of it, cut a strip of 18 s.w.g. sheet copper about $\frac{1}{4}$ in. wide, the full length of the wrapper less the width of the flanges of the throatplate and backhead, lay this on the inside and secure with four $\frac{3}{4}$ in. dia. copper rivets, countersunk both sides for neatness. If both the wrapper and the strip are rubbed with very coarse emery and then given a short spell in the pickle tank, the silver solder will penetrate the whole joint and the resulting wrapper will be as strong, or stronger, than a one-piece job. Incidentally, to make a good job, bevel off the edges of the lap strip, top and bottom, before riveting to the wrapper and extension sheet.



Throatplate

The throatplate is a very simple one, made from $\frac{1}{16}$ in. or 16 s.w.g. copper sheet. The former can be cut from a piece of $\frac{1}{8}$ in. thick bright mild steel, and no-one should have any difficulty in flanging this plate. There is however one point to watch. Be sure that this plate is cut long enough at the top edges to completely fill the gap where the firebox wrapper splays out from the barrel; so before cutting quite up to the scribed lines, "offer up" the throatplate to the boiler and mark where metal has still to be removed. When satisfactory, rivet the throatplate in position, using not more than two rivets each side, $\frac{3}{4}$ in. dia. is plenty big enough if you can get them, otherwise $\frac{1}{2}$ in. dia. and countersink both sides for neatness. Which reminds me, I read somewhere that all rivets used in boiler construction should be snaphead, not countersunk. This may be a good general policy in the larger

Below: Another view of the "Princess of Wales" under construction by Mr. G. E. Thornton of British Columbia (see page 137)



boilers, and certainly in all-steel boilers, but in a small boiler like *Green Arrow's*, snap heads would be ugly and clumsy, and as all joints are to be silver soldered, quite unnecessary from the strength point of view.

Tackle the other plates now. For the smokebox tubeplate and backhead, I am specifying $\frac{3}{8}$ in. thickness. Although this takes a bit of flanging in such small sizes, it has the big advantage that it gives just enough threads to allow us to dispense with the need of bushes for such things as the blower valve and smokebox blower connection. Also no longitudinal staying is required, the blower tube being put through the boiler purely as a matter of convenience in getting the steam to the front end.

Beginners may find trouble in flanging the smokebox tubeplate. The secret is to keep on annealing immediately the copper starts to go hard. You may find it necessary to anneal 6 or 7 times before success is achieved. Patience is indeed a virtue! As this plate can be skimmed in the lathe, to obtain a nice push fit into the barrel, don't forget to make the former large enough in diameter to allow for this.

As far as the firebox tubeplate is concerned, the sharp bend should be put in after flanging, and after making a saw-cut at the point of bending, the exact angle being determined by placing the plate against the sloping throatplate, and bending until the upper part of the plate stands up at 90 deg. Mark out and drill the six positions for tubes and flue $\frac{1}{8}$ in. dia. to start with, then clamp this plate to the smokebox tubeplate but allowing for the $\frac{3}{8}$ in. rise of the tubes, then run the drill through the second plate.

Drill the firebox tubeplate for the tubes and flue very slightly undersize, but the holes in the smokebox tubeplate may be drilled and reamed to final size. Countersink all holes in each plate on the side nearest to the front of the boiler.

Now tackle the firebox backplate. A piece of thick-walled copper tube will be needed for the firehole. $\frac{7}{8}$ in. O.D. \times $\frac{3}{8}$ in. thick wall will be about right. Turn this down first, to form the two steps, then anneal and squeeze gently in the vice. The exact shape that emerges from this treatment will not matter at all, as the tube can be pressed against the firebox backplate and the scriber point run around it. No other holes are required in this plate, so fit the firehole tube to the plate, lightly flange over, then silver solder using B.6, C.4, or Argobond, as preferred.

Prepare the backhead, flanging as before, but don't drill any holes in this just yet. We can now return to the inner firebox wrapper, which is made from the 18 s.w.g. sheet, and should prove a very simple bending job. To make the fitting of this sheet even easier, stand the two firebox plates on a piece of thick wood, and arrange other pieces of wood so as to hold the two plates in their correct relative position, while the wrapper is trimmed to fit. Use as few copper rivets as possible to get the wrapper to stay close around the flanged plates; then tackle the two crownstays, which are nothing more than slices of the $\frac{3}{8}$ in. thick copper bent into an L shape. Two rivets to each of these will hold them on, when the whole inner firebox may be silver soldered, using Argobond or Easyflo No. 2 this time, as preferred.

To be continued

SMOKE RINGS

Continued from page 163

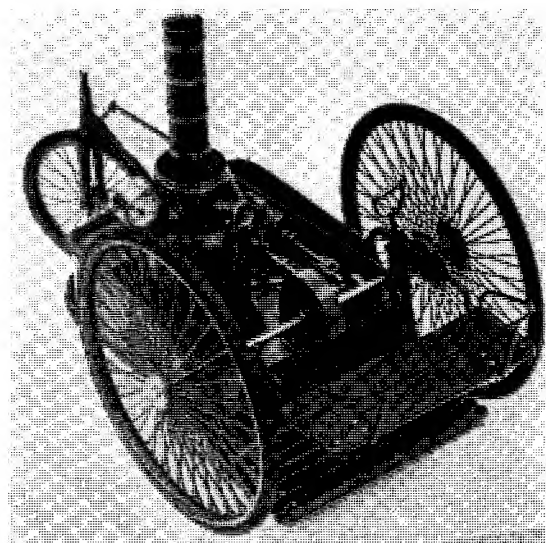
long \times 8 in. high. The tyres are vacuum cleaner belts. The engine is a horizontal double-acting slide valve type of $\frac{7}{8}$ in. bore and $\frac{1}{16}$ in. stroke, driving the rear axle by 4-1 spur gears.

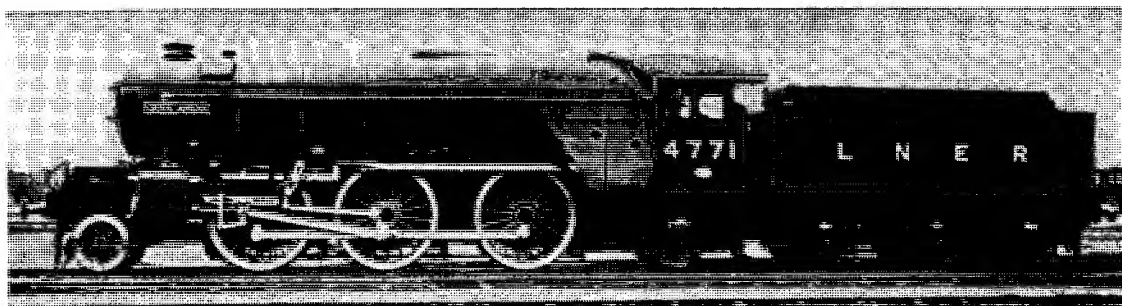
The boiler is a copper centre-flue, $1\frac{1}{2}$ in. diameter \times 3 in. high, with $\frac{1}{8}$ in. flue. The working pressure of this model is 60 p.s.i., and it runs well at 4 to 5 m.p.h. for 10-15 minutes on its methylated spirit burner.

Blenheim Rally

The Annual Blenheim Rally of the Witney & West Oxfordshire Society of Model Engineers, which is normally held over the Spring Bank holiday, will this year be on Saturday, May 20th. Tickets for entry to Blenheim Park can be obtained from the Secretary, R. C. H. Chilton, 41 Waverley Avenue, Kidlington, Oxford.

Another view of Mr. Harling's model steam tricycle





GREEN ARROW

A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2, designed and described by Martin Evans

Part IX

Continued from page 137

THE NEXT STAGE in building the boiler is to fit the tubes and superheater flue. First, file three or four nicks, about 12 thou deep, in each of the tube holes in the firebox tubeplate; this will ensure that the silver solder penetrates properly. Now cut the tubes and flue to length, clean up the ends that are to fit in the smokebox tubeplate with coarse emery cloth, but the ends which are to fit into the firebox tubeplate should be turned down in the lathe, removing just a light skim, so that the tubes are a tight push fit in the tubeplate.

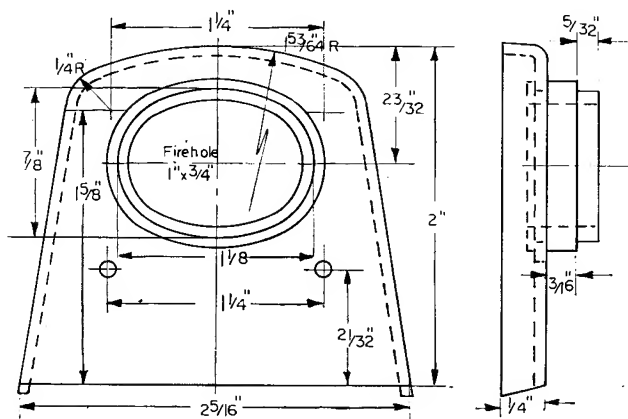
Set up the inner firebox, with the tubeplate on the top, and twist in the tubes up to their shoulders (formed due to the turning operation just mentioned). Put on the smokebox tubeplate, which will keep the tubes lined up, and check that the tubes stand out from the tubeplate with a slight rise towards the smokebox end. Wrap some Easyflo wire around each tube, pushing the rings so formed hard up against the tubeplate, flux well, and silver solder, keeping the flame on the move and mainly inside the firebox, so as to heat the tubeplate uniformly. After pickling and washing, the outer ends can be heated to redness to soften them before assembly.

The inner firebox should now be ready for assembly in the outer shell, so the front and side sections of the foundation ring can be cut and fitted, and the smokebox tubeplate pushed home and secured with two or three gunmetal or copper screws (8 BA would be plenty big enough here). The tubes and flue are now lightly expanded by a taper drift, after which this tubeplate and the tube ends are silver soldered.

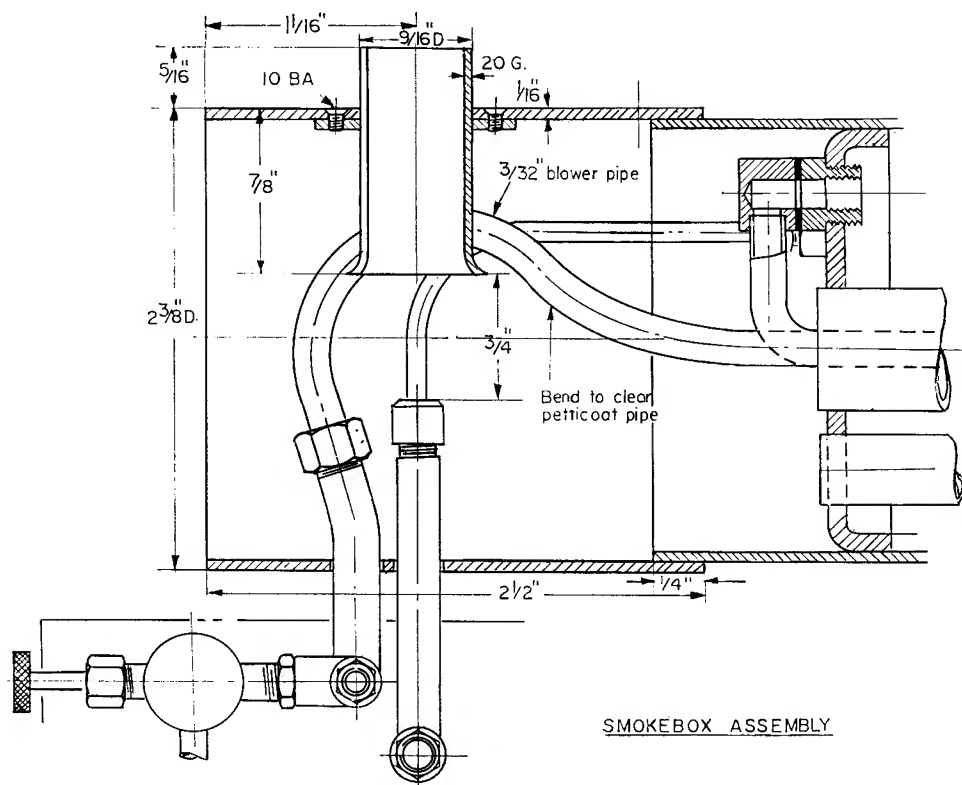
The next operation is to complete the backhead. This should therefore be offered up to the boiler

and the oval hole to receive the firehole ring marked out and cut. The regulator flange is turned up from gunmetal, pressed home and silver soldered on the back, using a higher melting point than Easyflo for preference. Push home the backhead, tapping the outer wrapper into close contact with it all around, then cut and fit the rear section of the foundation ring— $\frac{3}{16}$ in. square copper. Incidentally, all four sections of the foundation ring should be bevelled off on their lower edges, which will assist the penetration of the silver solder. A few gunmetal screws can be used to hold the backhead in position, and two $\frac{3}{8}$ in dia. copper rivets to each section of the foundation ring.

Before silver soldering the backhead and foundation ring, the firehole ring can be lightly flanged



FIREBOX BACKPLATE $\frac{1}{16}$ " COPPER SHT



over, supporting the boiler on a stout steel bar in the bench vice.

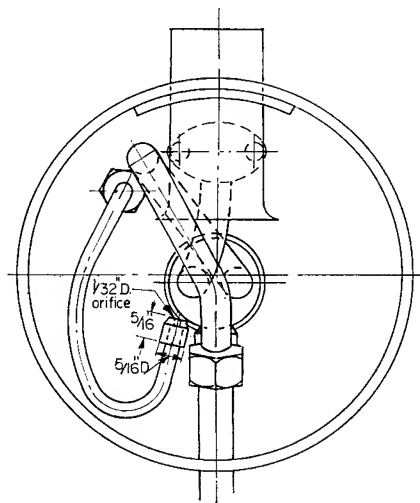
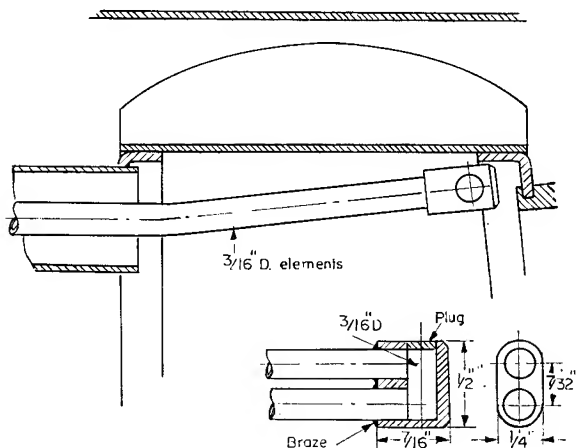
Bushes are now required for the two safety valves and the manifold (which will provide steam for the blower and pressure gauge, and a whistle if required) and these are all turned from gunmetal and tapped 1/4 in. x 40 t. A special "elbow" fitting will also

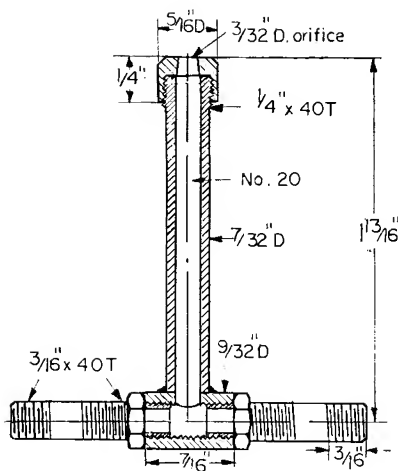
be needed for the top fitting of the water gauge. All bushes should be made a tight push fit into the boiler, and are silver soldered with Easyflo or a similar high-grade solder.

Preliminary Test

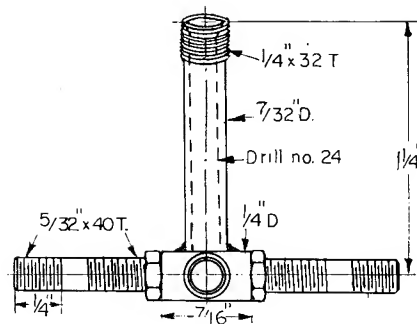
At this stage, the boiler can be given a preliminary

SUPERHEATER DETAILS

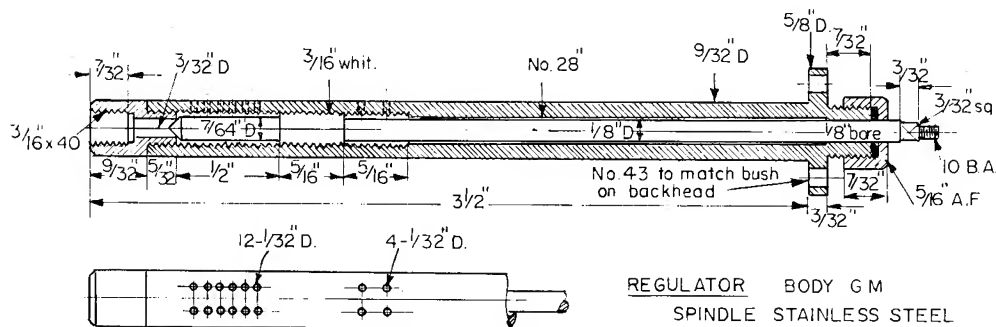
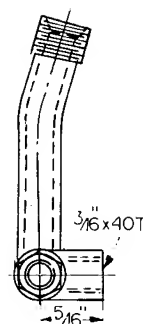




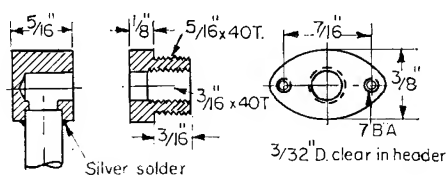
EXHAUST PIPE



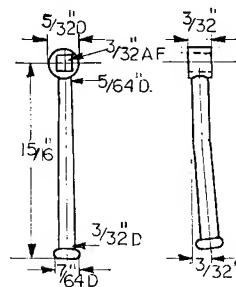
STEAM PIPE



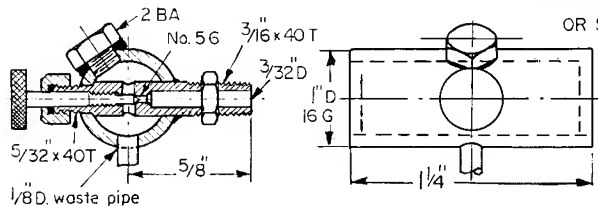
REGULATOR BODY G M
SPINDLE STAINLESS STEEL



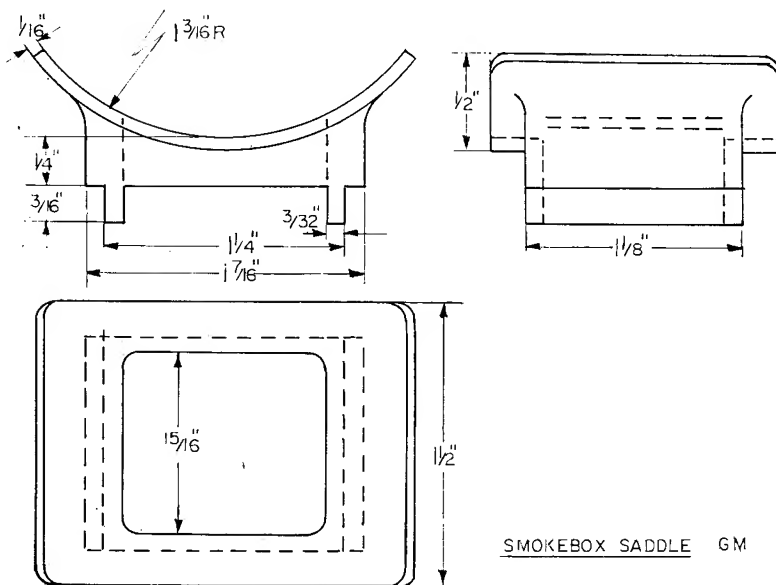
REGULATOR HEADER G M



REGULATOR HANDLE
B.M.S.
OR STAINLESS STEEL



DISPLACEMENT LUBRICATOR BRASS



Regulator

The regulator is a very simple affair, being merely a glorified screwdown valve. It would be rather extravagant to turn down the whole of the regulator from $\frac{5}{8}$ in. dia. gunmetal, so use a piece of $\frac{5}{16}$ in. dia., turn one end of this down to $\frac{1}{4}$ in. dia. and press it into a short length of $\frac{5}{8}$ in. dia. material, silver soldering the joint. The body is then skimmed down to $\frac{3}{8}$ in. dia. But before joining the two parts, drill and tap the body as shown putting a No. 31 drill and then a $\frac{1}{8}$ in. dia. reamer right through, opening out with a No. 28 drill, then opening out again tapping size for

hydraulic test. Make up a cover plate to match the regulator flange on the backhead—if this is made in steel, it can be used as a drilling jig for the regulator itself. This can then be bolted on with a "Hallite" or similar washer underneath it. A threaded plug can be made for the corresponding hole ($\frac{5}{16}$ in. \times 40 t.) on the smokebox tubeplate. Threaded plugs will also be required for the tapped holes for the blower, the two safety valve bushes and the water gauge bushes. Make all these plugs with their threads a shade on the larger side, and use a little plumbers' jointing on the threads. The test pressure gauge can be attached to the manifold bush and the test hand pump to the check valve tapped hole on the backhead.

Take the pressure up to not more than 25 p.s.i. at this stage, as the stays have not yet been fitted. This pressure will be found ample to show up any leaks, which can be dealt with in the usual manner—by thoroughly cleaning the offending spot, and using further silver solder plus a very fine copper plug or screw, as appropriate.

The firebox stays are now fitted. There are 15 8 BA stays, made from drawn gunmetal, to each side, five 7 BA stays in the throatplate and two 7 BA stays in the lower part of the backhead. These should all be drilled and tapped, the tap passing through the two plates. Ordinary commercial brass nuts can be used on the inside of the firebox, though I much prefer cap nuts here. Do not use ordinary commercial soft solder for caulking the stays. Silver solder makes the best job of course, but a high-melting point soft solder is quite satisfactory.

$\frac{1}{8}$ in. Whit. (No. 26) Drill the 16 steam entry holes $\frac{3}{32}$ in. dia. (a fine test of patience!) finally putting the Whit. tap through again, to remove burrs.

The end fitting, which takes the main steam pipe, is turned from $\frac{3}{8}$ in. dia. or the nearest larger gunmetal. It is threaded $\frac{1}{16}$ in. Whit. at the backhead end, drilled $\frac{3}{8}$ in. bore, and tapped $\frac{1}{16}$ in. \times 40 t. for the main steam pipe.

It is advisable to use a different metal for the valve and spindle. $\frac{1}{8}$ in. dia. stainless steel would be suitable, a short length of a similar material, threaded externally $\frac{1}{16}$ in. Whit., being pinned to it at the appropriate position. The threads should not be too close a fit. Stainless steel could also be used for the regulator handle, $\frac{1}{8}$ in. dia. being required for the handle proper, and $\frac{3}{8}$ in. dia. for the boss.

The regulator is fitted in the conventional way. It is inserted from the backhead, four 8 BA stainless steel or gunmetal screws holding its bolting flange to the bush on the backhead. The main steam pipe, which should be made of $\frac{1}{16}$ in. \times 20 s.w.g. brass tube, is screwed and soft soldered into the end fitting of the regulator, and its extreme (front) end is threaded $\frac{3}{16}$ in. \times 40 t. for a length of about $\frac{1}{4}$ in. Cut this pipe to such a length that it just protrudes through the tapped hole in the smokebox tubeplate, then it will not be difficult to get the threads of the "wet" header to engage.

The superheater elements may be in stainless steel, copper or mild steel, in that order of preference. Whichever metal is used, it is probably best to use the same metal for the "block return bend". (One of our regular advertisers can now

supply short lengths of flat stainless steel bar). Braze the joint and the "plug" with B.6 or some similar alloy of fairly high melting point, though if the return bend is arranged hard up against the top rear corner of the firebox, I do not think it will get overheated.

Smokebox

For the smokebox, we require a $2\frac{1}{2}$ in. length of $2\frac{3}{8}$ in. dia. seamless brass tube, $\frac{1}{8}$ in. thick. With any luck, this will "telescope" with the front end of the boiler barrel. But if it doesn't, as the copper will be very soft after the silver soldering operations, no-one should have any difficulty in either closing it in very slightly, or opening it out, as required. The smokebox overlaps the barrel by $\frac{1}{4}$ in. and can be held firmly to it by four 8 BA steel countersunk screws, the screwdriver slots of which can be "filled" at a later stage, so that they don't show.

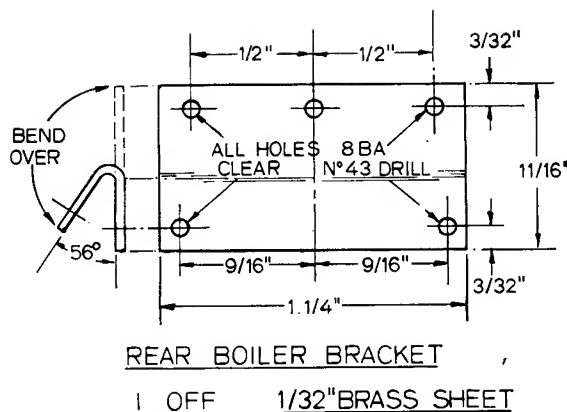
Although all Gresley engines were fitted with the usual circular snifting valve just to the rear of the chimney, I don't really think one is essential for a Gauge I locomotive. If any builder wishes to fit one, it would not be difficult. A short length of square gunmetal, about $\frac{1}{4}$ in. section, could be screwed into the superheater header horizontally, long enough to come below the "scale" position for the snifter, which could be put through a hole in the smokebox and screwed directly into the square fitting.

The petticoat pipe is made from a length of $\frac{1}{8}$ in. brass tube, 20 s.w.g. thick. Anneal the lower end thoroughly, then it can be "spun" in the lathe to the shape shown. The pipe is held to the underside of the smokebox by two lugs, tapped 10 BA, for countersunk screws put through from the outside.

I expect that a gunmetal casting will be available for the saddle. The curved surface, on which the smokebox rests, can be fly-cut, the tip of the cutter being arranged to describe a radius of $1\frac{3}{8}$ in. The sides, front and rear can be filed, but the bolting flanges, which lie between the frames, to which they are bolted by three 8 BA countersunk screws, should be end milled if possible. To do this, clamp the saddle down (upside down) on an angle plate attached to the vertical-slide, which is set up facing the lathe headstock.

The height of the saddle of course determines the height of the boiler above the frames; the rear end must be adjusted until the barrel is truly horizontal.

The fixing down of a wide-firebox type boiler at the rear end is always rather a problem. As far as this model is concerned, it is important to keep the back of the ashpan clear, so that the grate can be removed without difficulty. It is not really convenient to attach angles to the sides of the firebox, and with the shape of the trailing frames,



it would be difficult to find anything to bolt them down to anyway. So the solution is a thin plate, made of hard brass about $\frac{1}{32}$ in. thick, screwed to the front section of the foundation ring, and bent as shown in the drawing, so that two screws can be put through into the point where the trailing frame angles are held to the main frames.

Displacement lubricator.

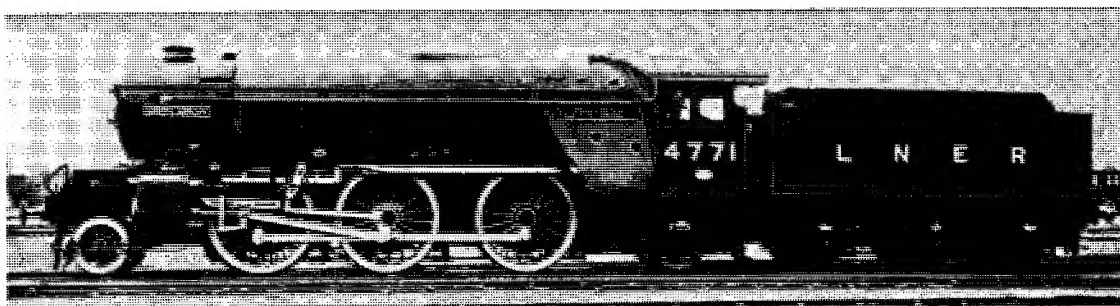
There would just be room for a small mechanical lubricator between the frames, ahead of the cylinders, but I expect that most Gauge I builders will be satisfied with the simple displacement type. This one has its oil container made from a length of brass tube $\frac{1}{2}$ in. diameter and $\frac{1}{8}$ in. thick, long enough to span the frames, to which it could be held by a screw put in from the side if desired. The valve body is made from $\frac{1}{8}$ in. dia. brass or gunmetal, cross-drilled as shown, and threaded $\frac{1}{8}$ in. \times 40 t. to screw into the steam "tee". With this arrangement, the lubricator has to be assembled together with the tee, but if it is desired to have the lubricator easily detachable from the tee, a union connection will have to be introduced between the two.

To be continued.

EAST ANGLIAN FARM WAGON

Continued from page 232

resistance wire culled from an old starting switch. To get these things right, a farmer relative gave me a full size set of harness from which I made paper patterns to $\frac{1}{10}$ full size and was very pleased when I found they fitted without much adjustment. Draught excluder strip was used for horse brasses and other decorations and a spot of colour to brighten things up was given by painting the wooden hames and saddle bridge the usual bright red—fifty-fifty 'Humbrol' red and orange. Apart from the cost of the horses, my expense account was very low. As I wished to be certain that all the wood was dry and well seasoned, I got it from coat hangers, chair legs, and an old piano. ✠



GREEN ARROW

**A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2,
designed and described by Martin Evans**

Part XI

Continued from page 248

Boiler Test

IN MY LAST article on *Green Arrow*, where I dealt with the completion of the boiler and the making of the regulator, smokebox and lubricator, I forgot to mention the hydraulic testing of the boiler, which of course should have been done after all the stays had been fitted and before starting on the backhead fittings.

The hydraulic testing of model boilers has been described many times recently in "M.E.", but for the benefit of newcomers to the hobby, I will run over the operation briefly.

All bushes, except one of those on the top of the boiler, should be carefully plugged, using a little plumbers' jointing on the threads, and the regulator flange blanked off as described on page 247. The blower tube should also be fitted, so it is a good plan to make this up, together with the blower and the union connection for the smokebox end; alternately, fit the tube temporarily with a "blind" nipple at each end, these nipples having external threads $\frac{1}{4}$ in. \times 40T, and internal threads $\frac{3}{8}$ in. \times 40T, the blower tube itself being thick-walled copper tube $\frac{5}{8}$ in. O.D. \times 18 s.w.g.

A large reliable pressure gauge reading to about 300 p.s.i. is screwed into the "spare" bush on the top of the boiler, and any suitable hand pump is attached to the check valve bush on the backhead.

The boiler is completely filled with cold water, all air being excluded, and the pressure is then brought up gradually to 200 p.s.i. by using the hand pump, which can be set up in a shallow tray of water. If the boiler seems quite satisfactory at this pressure, which should be retained for about 15 minutes, it can be safely passed for service.

Ashpan

The shape of the ashpan is of necessity rather complicated. The trouble is that the foundation ring of this boiler is not a true rectangle, but is tapered in towards the rear, due to the slope of the grate towards the front.

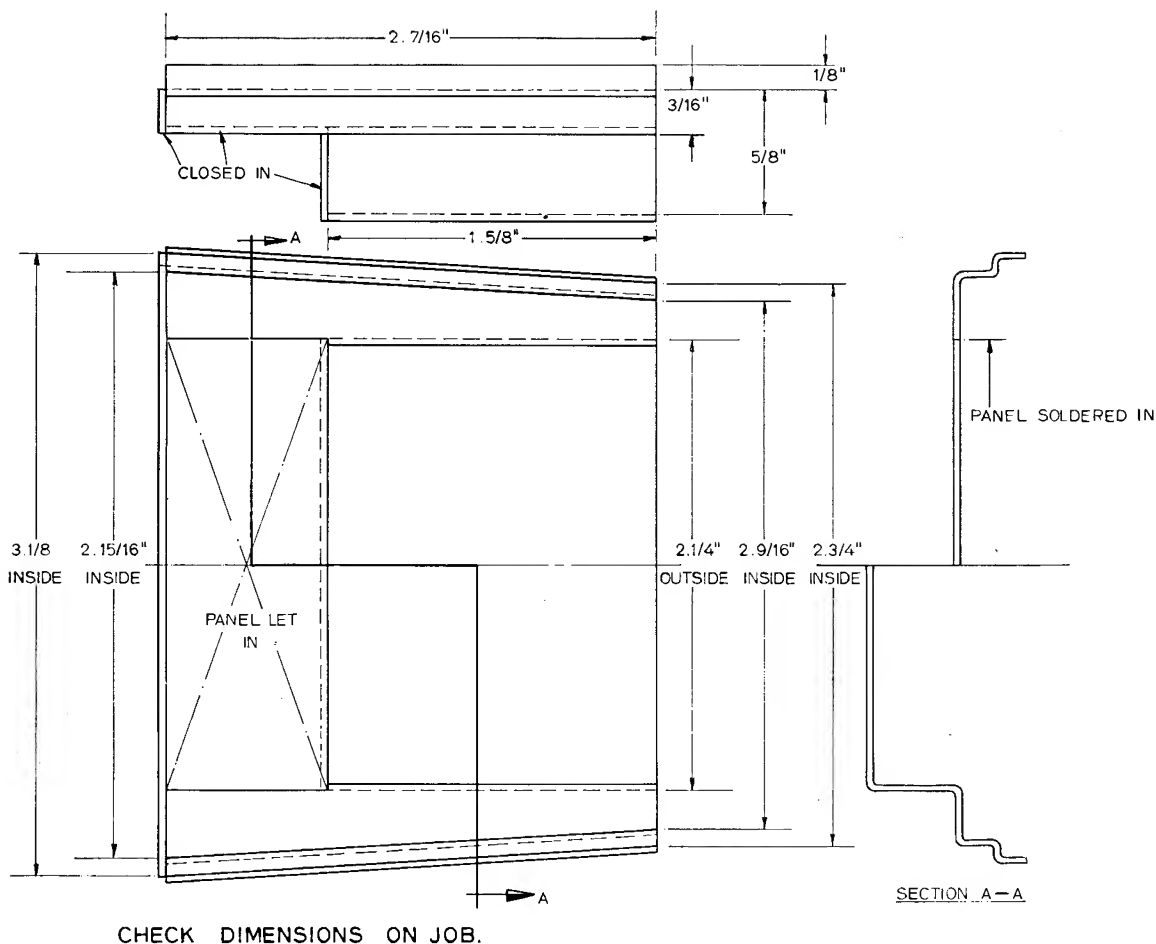
It will be noticed that when the boiler has been bolted down at the smokebox end, and held down to the frames horizontally by the special bracket described in the last issue, there is a gap between the underside of the foundation ring and the top edge of the trailing frames $\frac{1}{8}$ in. deep. The ashpan has been designed to slide into this gap from the rear, hence it is made to a depth of $\frac{1}{8}$ in. only, where it lies above the top edges of the trailing frames, though it is $\frac{5}{8}$ in. deep *between* the frames.

To ease the bending operations, the material for the ashpan should not be thicker than 22 s.w.g. and all joints can be brazed, which makes for a neat job.

Before starting to make the ashpan, check all the dimensions of your own boiler first; there are bound to be a few small variations – boiler making is hardly an exact science! It would be well worth while making a steel former to ensure getting the bends in the right places.

Returning now to the remaining boiler fittings, two safety valves are required, and these are of a very simple ball type, made from $\frac{3}{8}$ in. A/F hexagon gunmetal. I am afraid that if these valves are to work as they should, they will have to be considerably out of scale. They will protrude through the holes in the cab roof by about $\frac{1}{4}$ in., not allowing for the "trial pin".

Stainless steel balls $\frac{1}{8}$ in. dia. on $\frac{3}{8}$ in. reamed



ASH PAN

I OFF

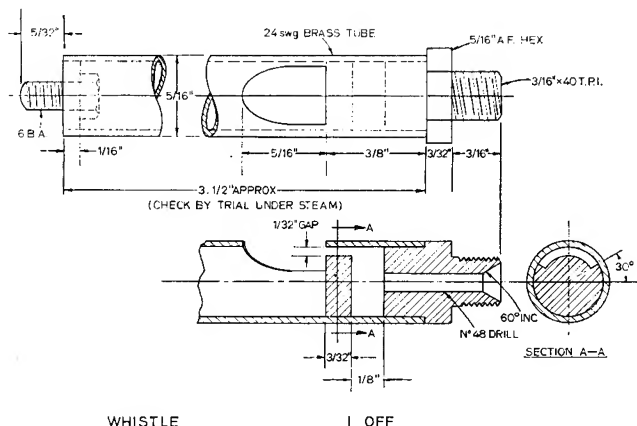
22 swg STEEL

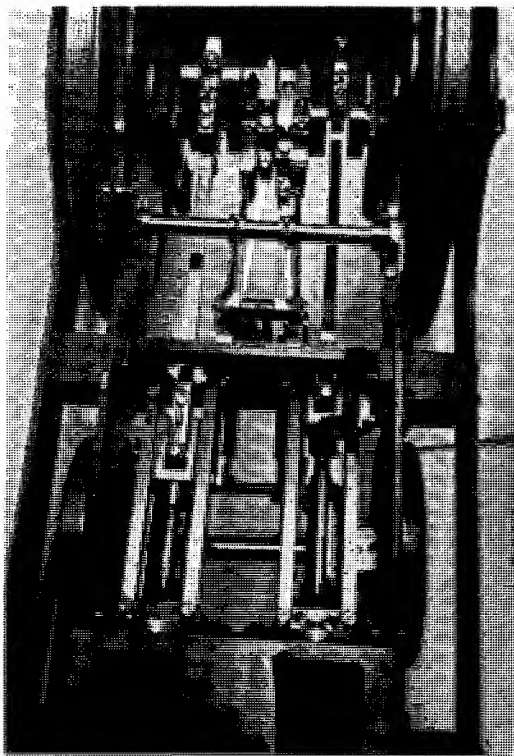
seatings are used, and the springs should be determined by trial and error, setting the valves against the master pressure gauge under steam.

Little need be said about the blower valve and the smokebox connection for the blower; the former can be built up from two pieces of round gunmetal, $\frac{3}{8}$ in. and $\frac{7}{8}$ in. diameters, silver soldering the joint. Having "blended" the two parts in together, the "tee" so formed can be held in the 4-jaw chuck for machining and threading the branch, while the 3-jaw can be used for the other two ends.

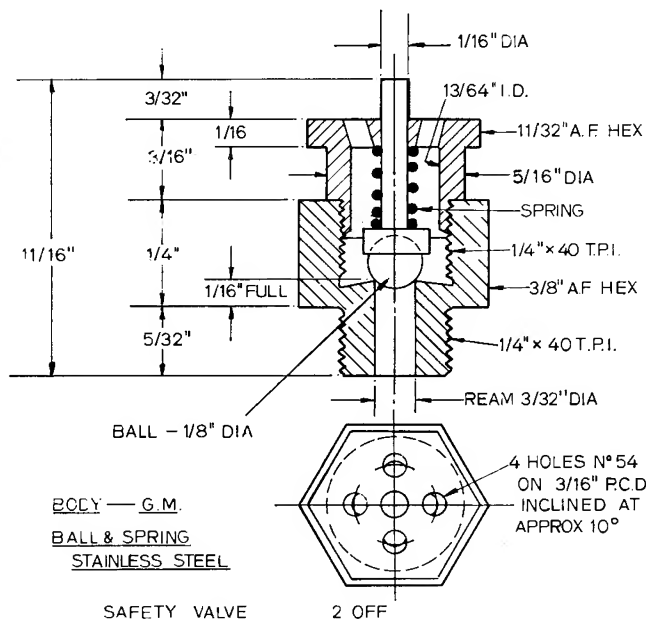
Note that for bottled-gas firing, a smaller orifice is preferable.

The water gauge is also quite straightforward, but the combined manifold and whistle valve needs rather more care as we have very little clearance here, under the cab roof. The "body" of this fitting is made from $\frac{1}{4}$ in. square brass, and

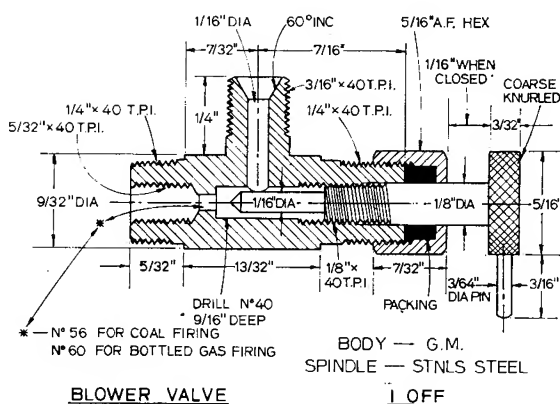
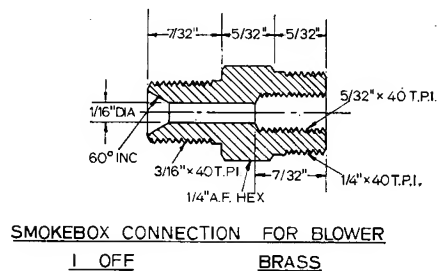
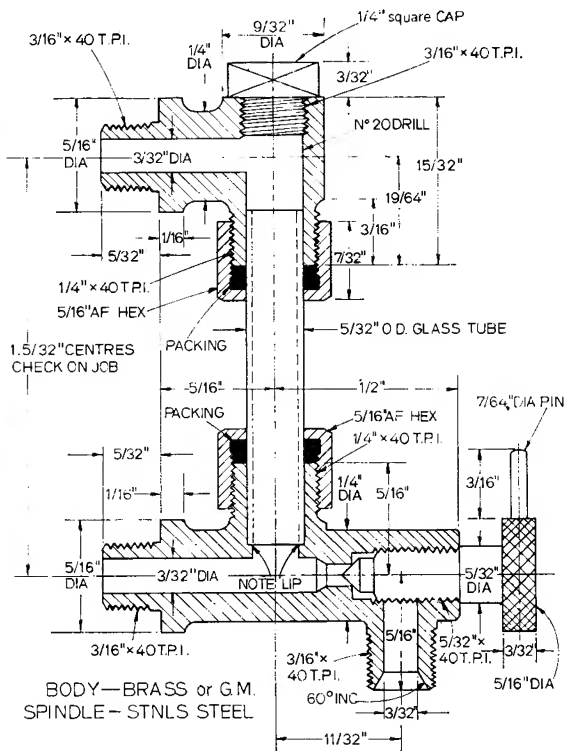




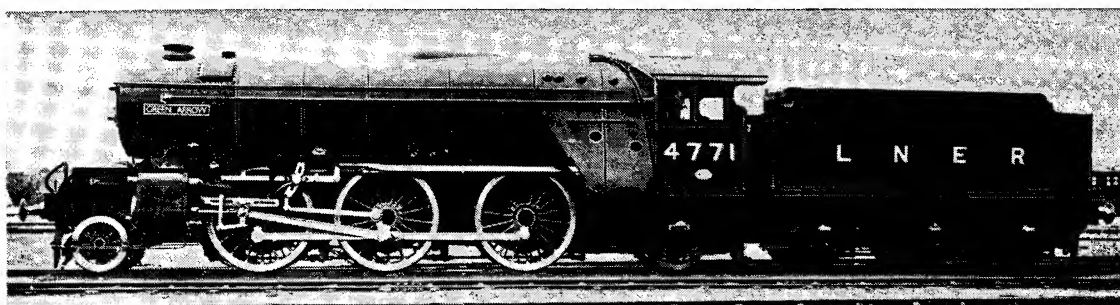
Another view of the "Princess of Wales" being built by Mr. G. E. Thornton of British Columbia.
Note the driving arm for the mechanical lubricator.



MODEL ENGINEER 17 March 1972







GREEN ARROW

A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2, designed and described by Martin Evans

Part XII

Continued from page 284

WE NOW come to the question of the alternative bottled-gas firing for the *Green Arrow* boiler. Although the same boiler as was specified for the coal-fired version could be used for bottled-gas firing, the fire-tubes are really too large in diameter, and a much more efficient boiler can be made if $\frac{1}{8}$ in. o.d. tubes are used in lieu of the $\frac{3}{8}$ in. tubes in the original boiler. There should be room for eleven tubes, as can be seen in my drawing, without running too close to the bottom of the barrel.

The only other alteration desirable is that the blower jet for bottled-gas should be somewhat smaller than for coal-firing, as only a moderate draught is called for. Too strong a draught could easily put the flame out.

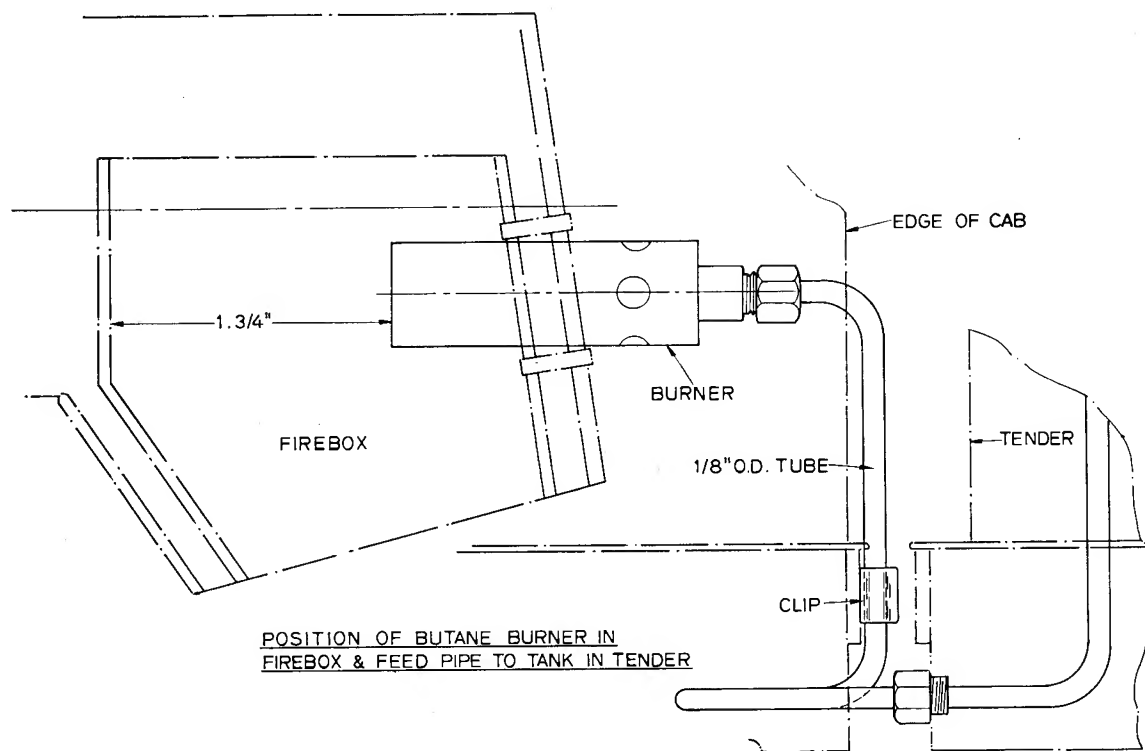
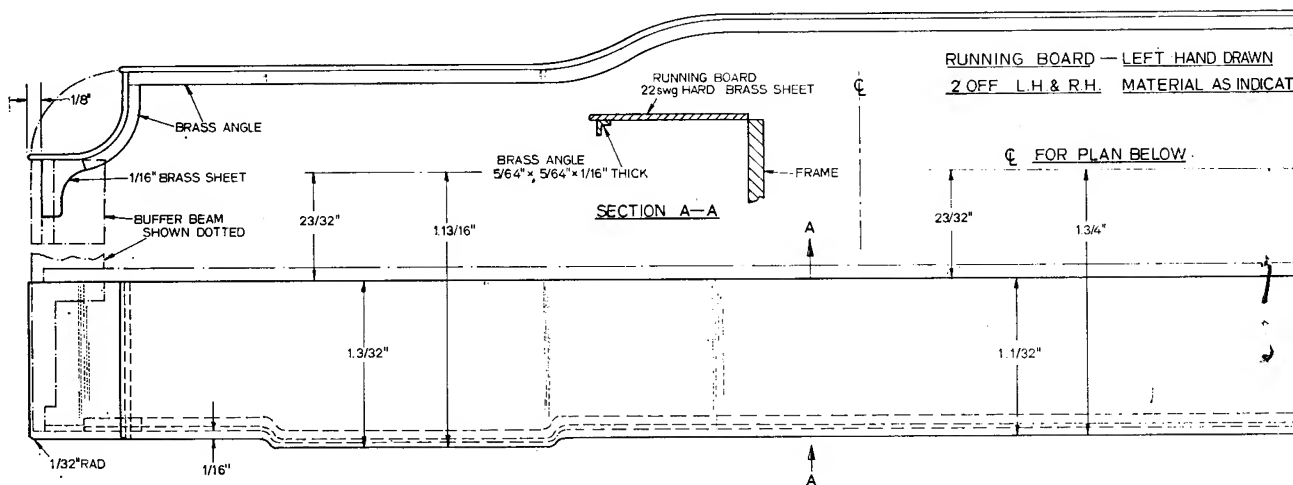
The next question which arises is whether to use propane or butane. At a room temperature of say 75 deg. F, the gas pressure in a commercial propane cylinder is around 122 p.s.i., whereas in a butane cylinder it is about 23 p.s.i. Because of this big difference of pressure, it is necessary to use a pressure-reducing valve with propane. The refilling of a small propane container from a large cylinder is obviously a process requiring considerable care, whereas using butane, it is quite a simple matter. In fact, I understand that some owners of Gauge "O" and "1" steam locomotives with butane firing refill their gas containers from the larger refill supplied by the cigarette-lighter people, which can be bought from almost any tobacconist. I have tried refilling a small (model) butane container from a "Ronson" refill, using a standard bicycle valve as the non-return valve. The only modification I found necessary was to take off the plastic connecting tube and turn this down slightly in the lathe to a

more conical shape, when by pressing the Ronson refill hard down on the cycle valve, gas and liquid passed quite successfully into my container with very little loss of gas, the Ronson refill being upside down during this process of course.

But I think this method is rather an expensive way of going about it, and I would recommend that one of the larger commercial butane refills should be used. I have tried several makes, and find that the French "Camping-Gaz" is probably the most suitable and economical. Most readers will be familiar with the "Camping-Gaz" outfits, and the method of fitting the refills. All we have to do to modify any of the "Camping-Gaz" outfits for our purpose is to make up a connecting piece to take the butane to the non-return valve on the gas container, which will of course be in the tender of the *Green Arrow*.

Do not use a cycle valve in any case, as the rubber tube in the valve will not last long. A simple non-return valve using a spring-loaded stainless steel ball can be used, fitted with a pressure-tight cap, and this will be described when we come to the tender details. When engaged in refilling operations, care should be taken to shut the burner off, and see that there are no naked lights about. Smoking during this operation would be asking for trouble, especially where propane is concerned!

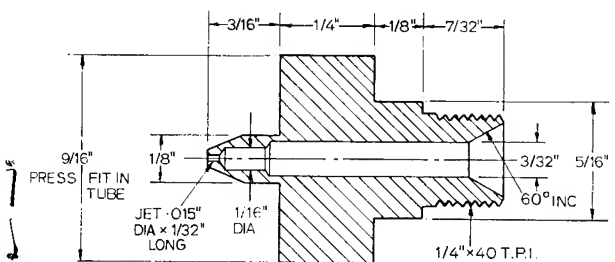
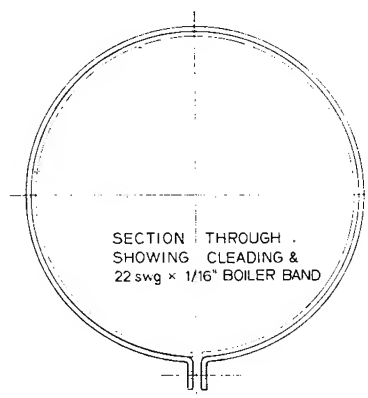
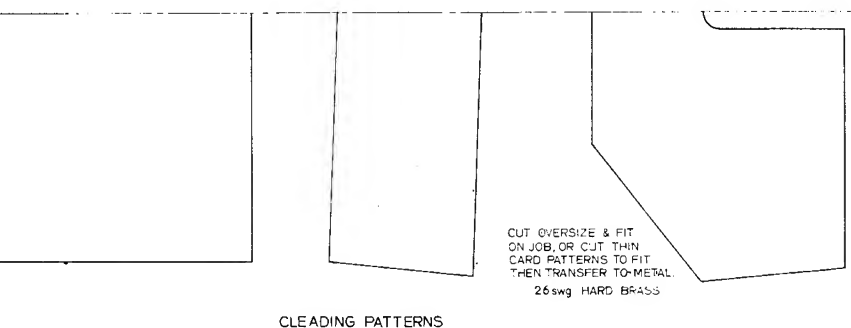
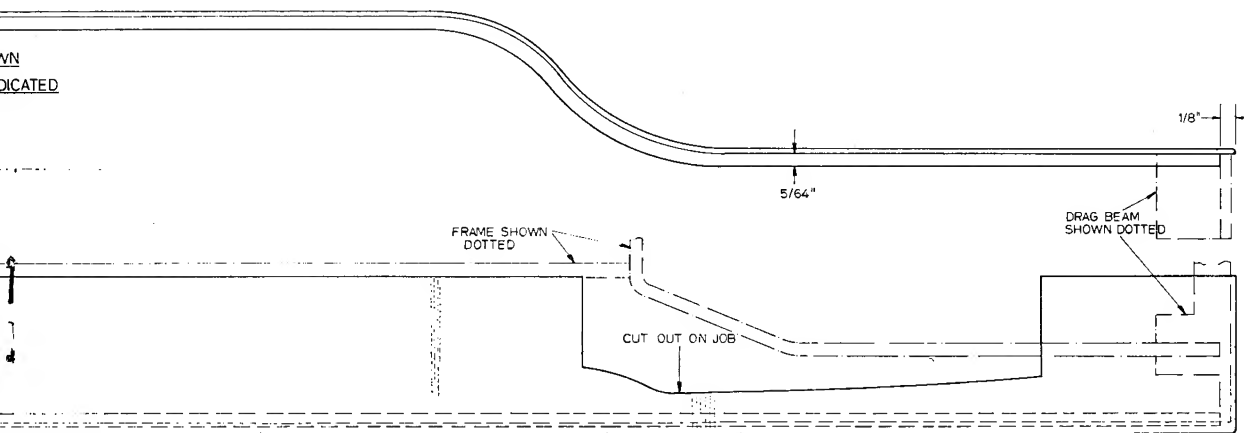
I have spent several hours experimenting with various shapes and sizes of burner suitable for our purpose, and the result is shown in the accompanying drawing. Rather to my surprise, I found that the position of the mouth of the jet in relation to the air holes is not particularly critical, but that shown will be found quite satisfactory. Again, the



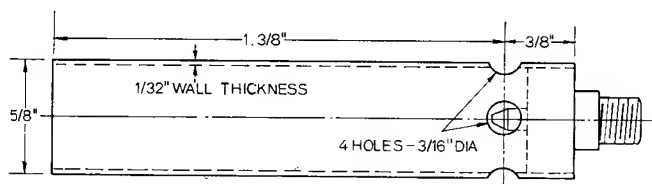
diameter and number of the air holes is not very critical. What *is* important is the diameter of the jet in relation to the diameter of the flame tube, which in this case is made from thin-walled brass tube $\frac{3}{8}$ in. diameter. Some very careful drilling will be called for to make the jet!

It will probably be asked whether it is necessary

to make the ashpan for the butane-fired version. If no ashpan is fitted, we would be left with an unsightly $\frac{1}{8}$ in. gap all round the bottom of the firebox, so I would suggest that a simple form of ashpan almost entirely open at the bottom, be made, to close this gap. As the butane burner is inserted through the same type of fire-hole as would have



BUTANE BURNER JET 1 OFF BRASS

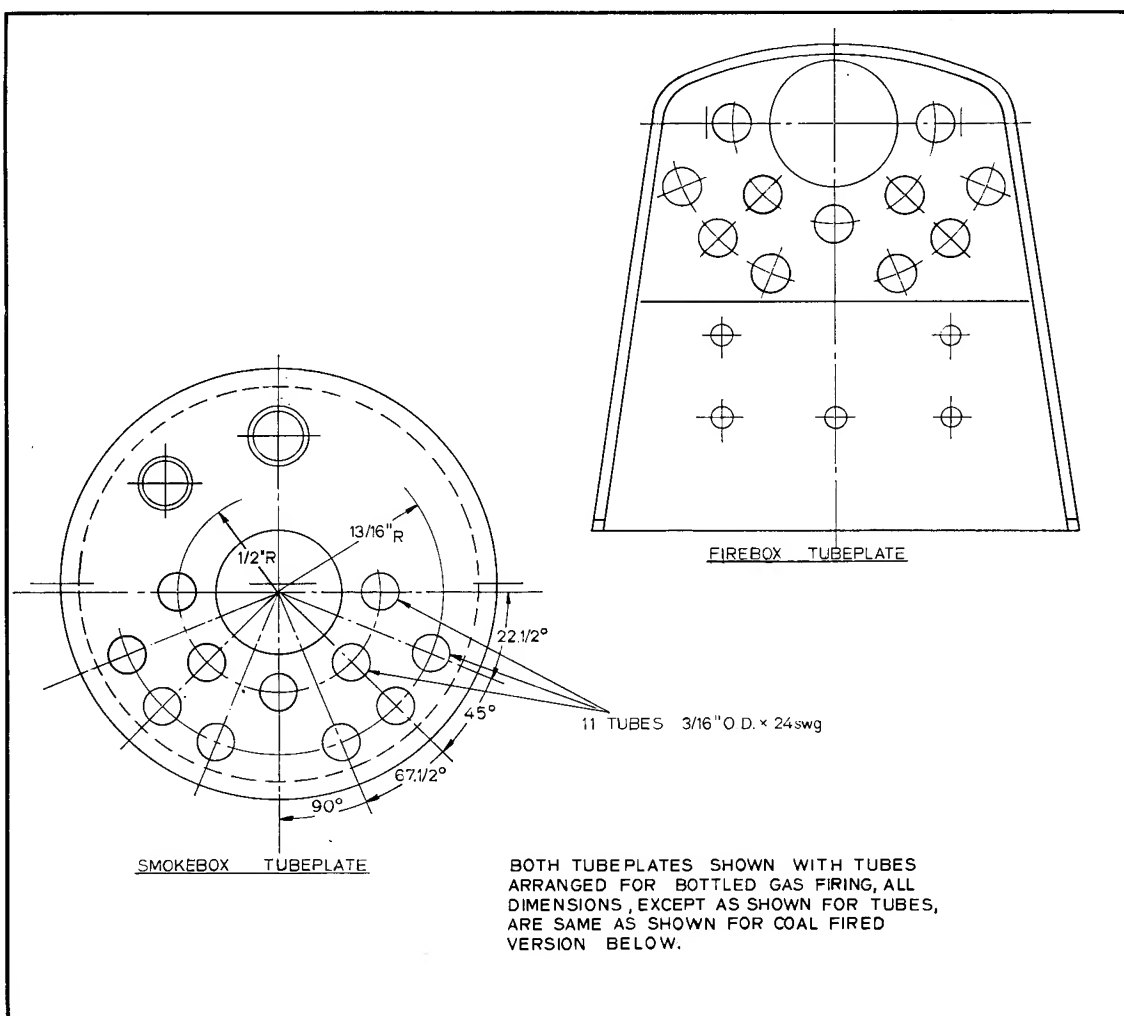


BUTANE BURNER 1 OFF $5/8"$ O.D. BRASS TUBE

been used for coal firing, it is essential to allow plenty of ventilation for the flame.

The butane burner is held by its own $\frac{1}{8}$ in. dia. feed pipe, which can be brought up against the engine drag beam and held there by a simple spring clip, as shown. It should not require any other fixing, and a proper "double-ended" union is used between engine and tender, each part of the feed pipe being given a couple of coils to provide the necessary flexibility.

To complete the engine itself, we now require the two running boards, plus two small pieces of sheet material to cover the space between the frames in front of the smokebox, and to provide a driver's "footplate" immediately to the rear of the backhead. All these pieces can be cut from 22 s.w.g. hard brass sheet, and the angle edging or "valance", made from brass angle, can be riveted and soft soldered as required. Do not make the "cut-out" for the firebox until you have decided about lagging. I would recommend that $\frac{3}{8}$ in. Walkerite steam shee



Details of boiler modifications required for butane firing.

packing material be used for the lagging, as there is not enough room for asbestos sheet. This can be covered with 26 s.w.g. hard brass cleading, which is made up in three pieces as shown, so as to simulate the taper in the boiler barrel; the joins are covered by the boiler bands and the "streamlined dome" (actually this is the cover for the steam collector

in the full-size "Green Arrow" Class engines).

To ensure that the lagging and cleading fits properly, cut out cardboard templates first and wrap them round the boiler and firebox. Cut them about with scissors until satisfied with the fit, then remove, flatten, and make the brass cleading to match.

To be continued.

GREEN ARROW DRAWINGS

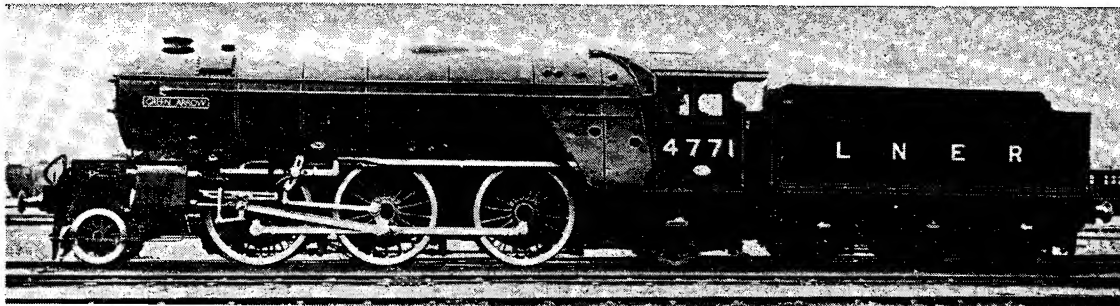
The following full-size drawings are now available:-
L.O. 939

- Sheet 1 General arrangement and valve gear details.
- Sheet 2 Frames, wheels, axles, axle boxes, coupling rods, cylinders, feed pump.

Sheet 3 Trailing and tender wheels and axles, axleboxes and horns. Full details of boilers, safety valves.

Sheet 4 Smokebox & superheater, saddle, backhead fittings, lubricator and ashpan.

Price 50p each, post-free.



GREEN ARROW

A Gauge I (10 mm. = 1 foot) model of Gresley's famous 2-6-2, designed and described by Martin Evans

Part XIII

Continued from page 340

THE SHAPE and dimensions of the cab sides and the "streamlined" cab front or weatherboard are best taken from the General Arrangement drawing. The original drawing of this was to twice full size, so any slight errors should be eliminated. I could of course give exact dimensions, but they would almost certainly be misleading, as all model boilers, especially after lagging and cleading, vary from one to another, and it is far safer to check the dimensions required from one's own job.

The cab sides and front can be angled and riveted in the usual way; but it would probably be wise not to fix the roof in the same way. Perhaps the best way to deal with the roof is to make it in two sections, a front piece, about half the total length, made a fixture, and the rest made to slide off for driving purposes. The "clerestory", surrounding the safety valves, can be built up with brass sheet and soft soldered. This might be made slightly higher than "scale" which would help to take the eye from the rather overscale safety valves.

The Tender

We can now turn our attention to the tender, which was of the standard L.N.E.R. 4,200 gallon type, with "uneven" wheelbase—a typical Gresley touch.

I have not gone into very much detail for the axleboxes and horns, as some builders may not bother to make these properly sprung. I believe that complete "solid" axleboxes, horns and springs are available from the Trade. However, a correctly sprung job is well worth while, and in fact even laminated springs might be tried, using strips of tufnol about 22 s.w.g. thick. I don't think there

would be any need to use metal for the top and bottom leaf, as we generally do in the larger gauges, an "all-tufnol" spring should be adequate in Gauge I.

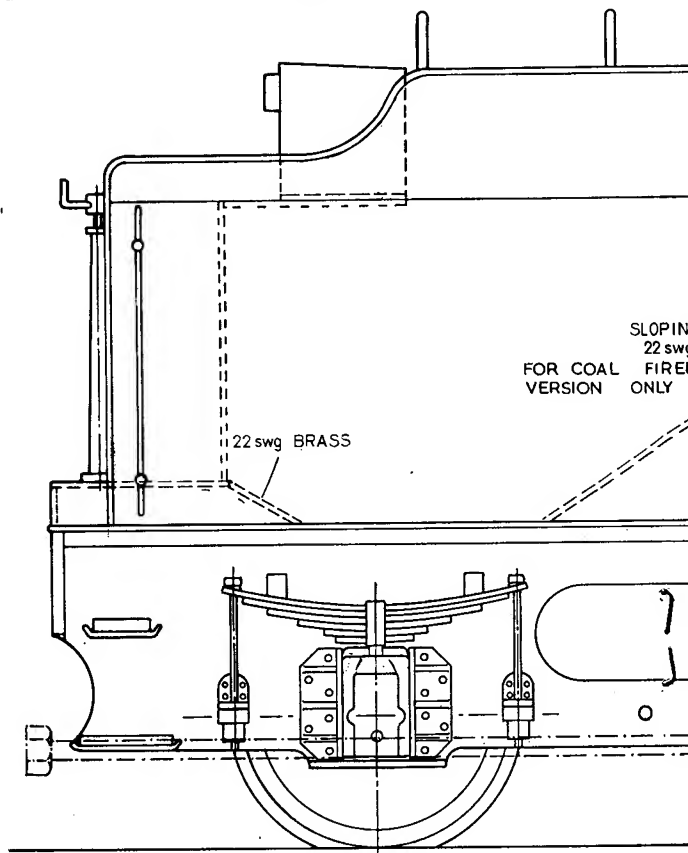
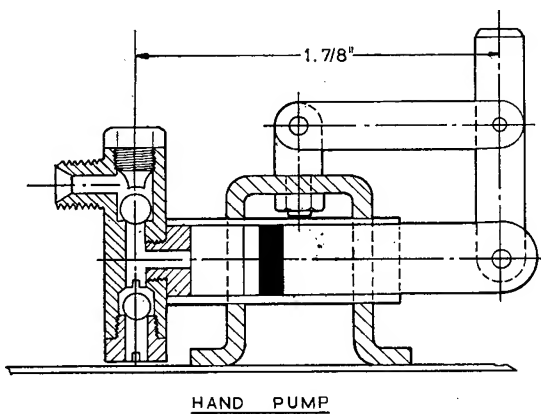
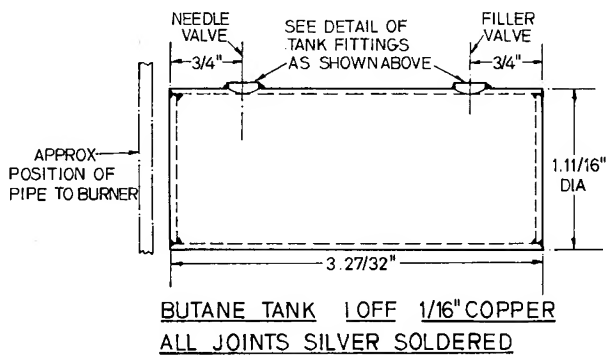
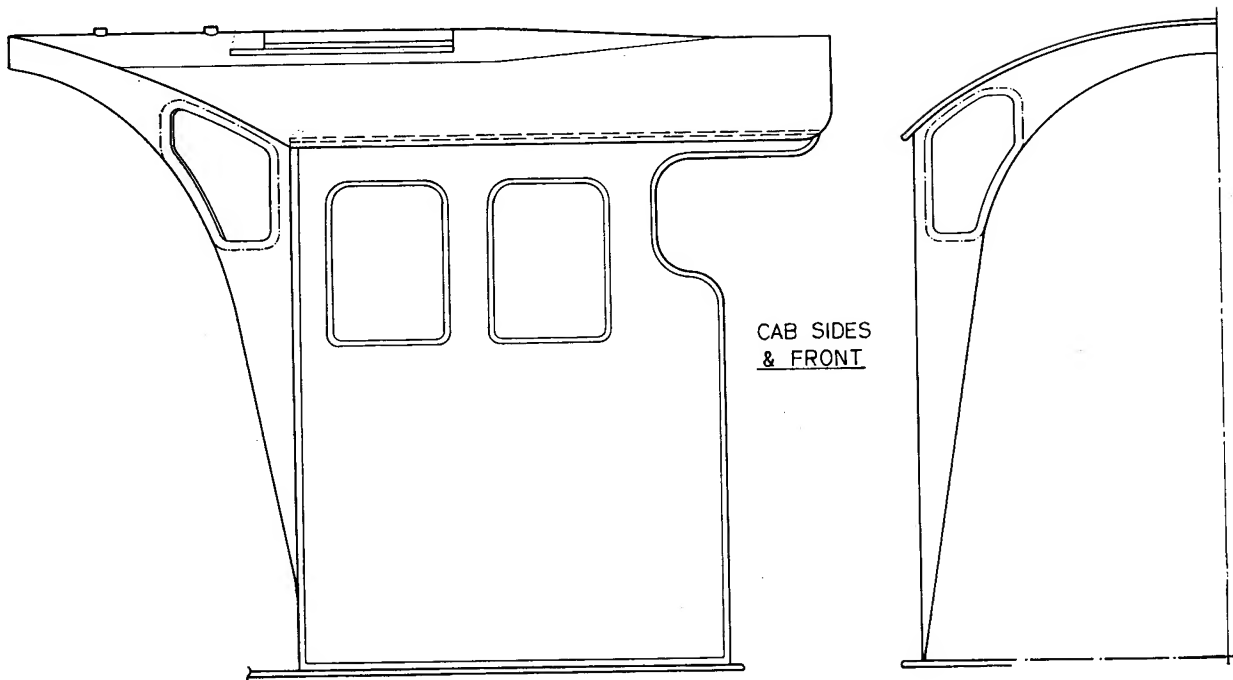
The frames need not be thicker than $\frac{1}{8}$ in., though once again we come up against the old problem of the buffer spindles fouling the ends of the frames—usually overcome by setting the frames further apart. The buffer beams can be milled, or sawn and filed, from brass bar, $\frac{3}{8}$ in. \times $\frac{1}{8}$ in. section, the frames being held to them by two BA screws at each corner.

I have not shown any frame stretchers, as I propose to leave these to the builder, but two round ones about $\frac{1}{8}$ in. dia. could be placed below the oval "lightening" slots, with their centres about $\frac{1}{8}$ in. up from the bottom edge of the frames.

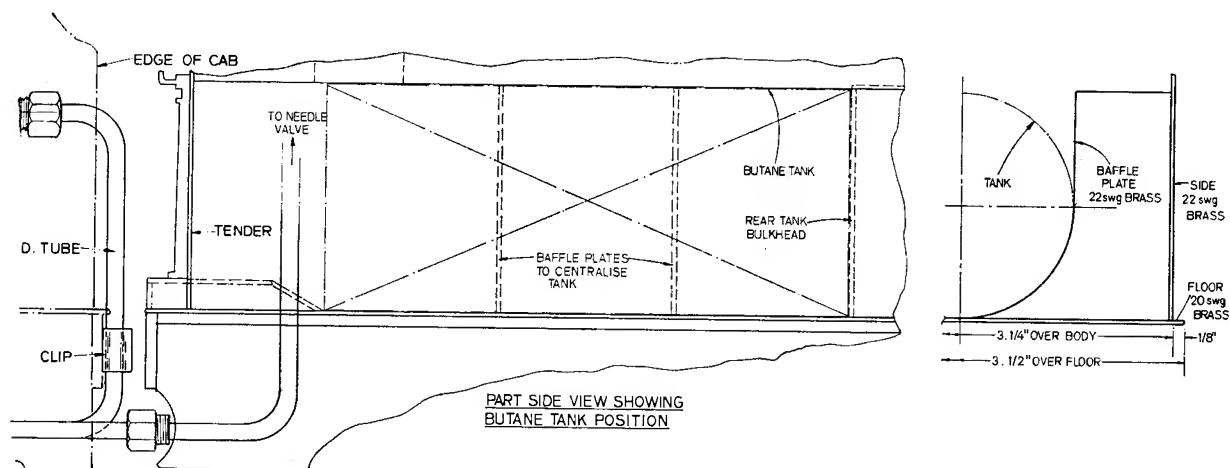
The body of the tender is built up from 22 s.w.g. hard brass sheet, with 20 s.w.g. for the floor. The various parts can be held together by $\frac{1}{4}$ in. \times $\frac{1}{4}$ in. brass angle, using rivets, 10 BA brass screws or even Araldite or Loctite, as preferred.

As far as the inside of the body is concerned, there will be some variations, according to whether coal or butane firing is being adopted. For coal firing, we will need the usual sloping bottom plate, with a cross partition at the front end, just ahead of the toolboxes, so as to have something to "shovel up" against. For butane, the sloping plate is dispensed with, but two cross members will be needed to locate the butane tank, which is cylindrical. The top deck will be the same in both cases.

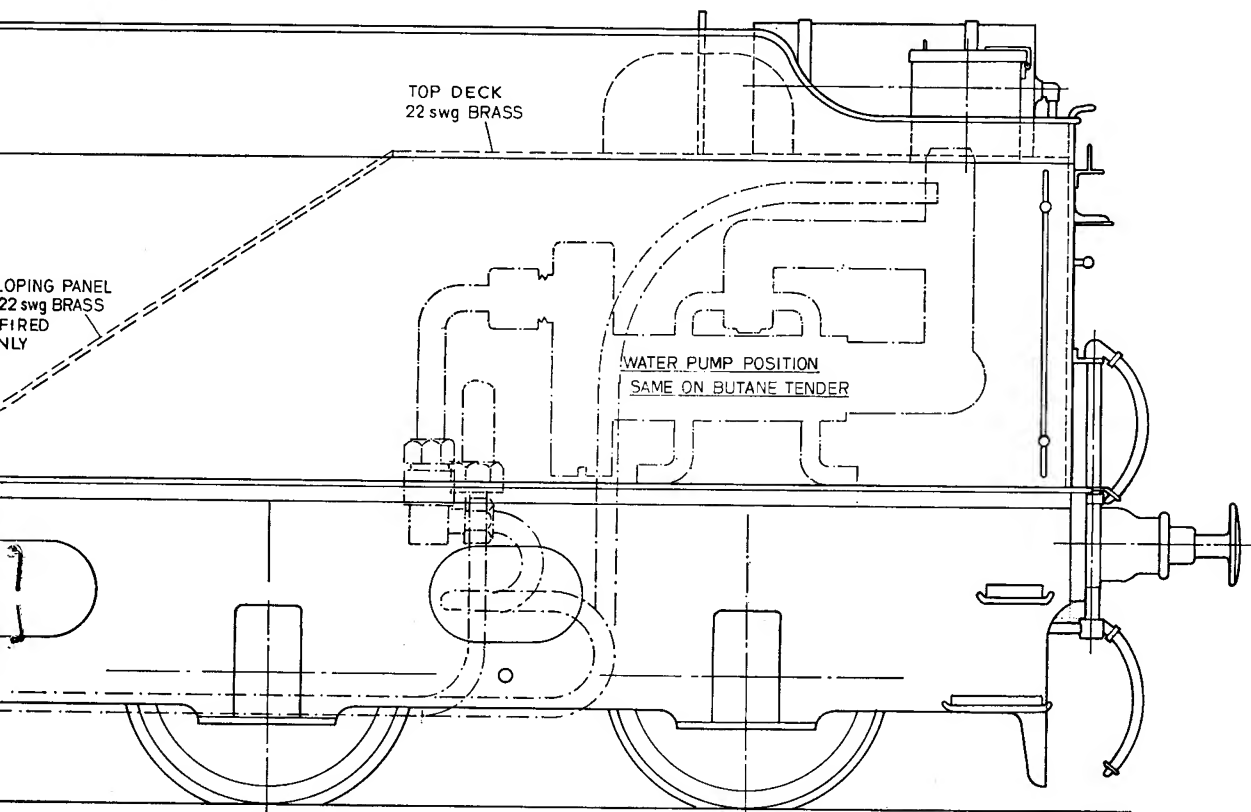
The hand pump should be off-set, to the right of the tender, so as to clear the water filler, but should not be placed so far out that the fixing screws come

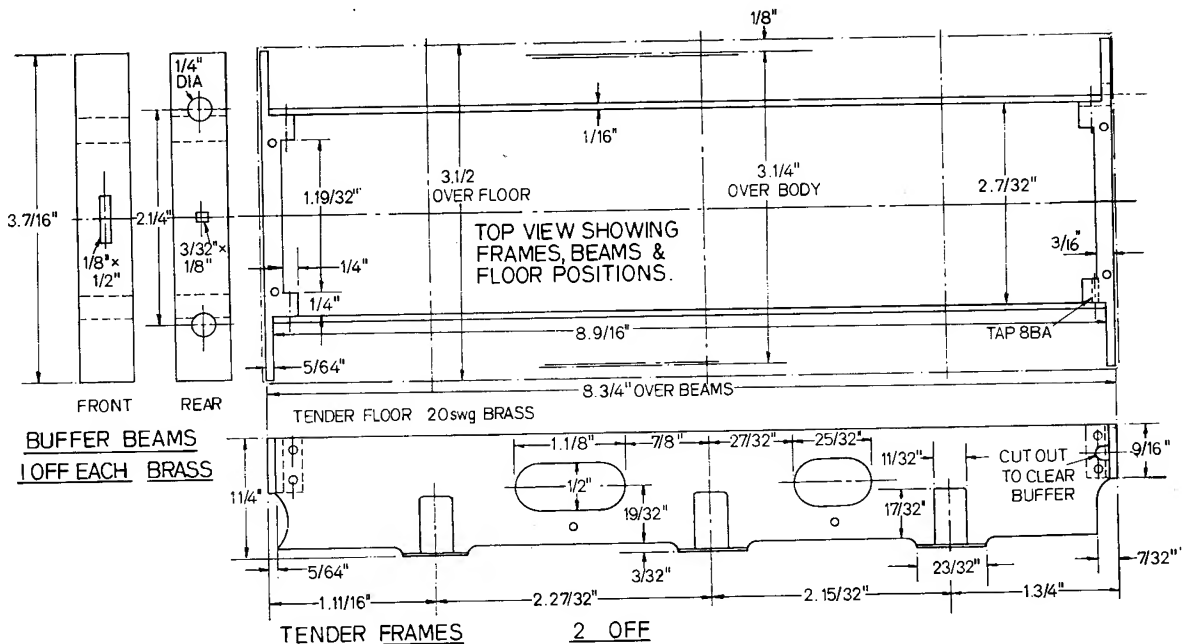


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TENDER DETAILS





outside the frames. The suction pipe and the by-pass pipe for the axle-driven feed pump (where fitted) can be brought back almost along the longitudinal centre-line of the tender, the outlet for the by-pass being located just underneath the water filler. These two pipes will only require short lengths of rubber tube to connect to the engine, the by-pass valve being placed underneath the cab floor. The hand pump, however, will need a proper double union.

Coming now to the butane tank and its accessories, the tank itself should be made from seamless copper tube, $1\frac{1}{8}$ in. dia. for preference, but if this size cannot be obtained, $1\frac{1}{2}$ in. dia. will do nicely, if the top deck etc. is raised the extra $\frac{1}{8}$ in. The ends must be properly silver-soldered. Two bushes are required in the tank, one tapped $\frac{1}{4}$ in. \times 40 t. for the control valve and the other $\frac{5}{16}$ in. \times 40 t. for the filler and non-return valve. The non-return valve incorporates a $\frac{1}{8}$ in. dia. stainless steel ball on a $\frac{3}{32}$ in. dia. reamed seating, and a light stainless steel spring ensures that the ball is always kept on its seat. The connecting thread on the top of this fitting is $\frac{1}{4}$ in. \times 40 t. and a short connecting pipe should be made up to suit this, the other end having a thread to match the "Camping Gaz" outfit, or whatever is used to supply the butane.

I do not think I need to detail out the hand pump, ordinary brass tube being quite suitable for the barrel, and the ram can be ground stainless steel or gunmetal, as preferred.

To conclude this short series of articles, a few words on the livery used on the "Green Arrows" in L.N.E.R. days.

The boiler, firebox, cab sides and front, side and back of tender were the standard "apple green". Smokebox, tops of running boards, cab roof, out-sides of all frames, inside of tender and cylinders, were black. Engines built at Darlington had the sides of cylinders painted green.

Wheels were green, with the ends of the axles black with a single white line between the colours.

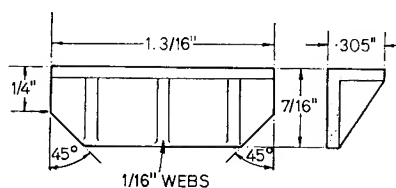
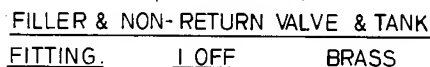
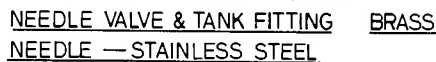
The insides of all frames were vermilion, also buffer beams. Drag beams were black. Buffer bodies black.

Lining on the boiler bands was black with a single white line on each side of the black. Similar lining was on the cab sides and tender sides in the form of rectangular panels with rounded corners. There were also single black and white lines along foot-plate and tender valances.

There was a single red line on the trailing frames, tender frames and on footsteps; the exact positions of these lines can generally be seen in a good photograph.

The lettering was gold shaded red and black. Originally, in L.N.E.R. practice, the letters were painted on the tender sides with the number below, but from 1929, numerals were placed on the cab sides, and as the "Green Arrows" did not appear until well after 1929, the later arrangement of numerals would be correct. Letters were more or less of Gill Sans design 12 in. high; the numerals were of the same height.

Nameplates of the named engines were cast in brass, with black backgrounds, the letters being raised and polished. Doncaster-built locomotives had the usual Doncaster oval "builder's" plate on



HORNBLOCK 12 OFF G.M.